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THE SEA

AND

ITS LIVING WONDERS

A POPULAR ACCOUNT OF

THE MARVELS OF THE DEEP

AND OF THE

PROGRESS OF MARITIME DISCOVERY FROM THE EARLIEST AGES TO THE PRESENT TIME

BY

DR. G. HARTWIG

AUTHOR OF "THE TROPICAL WORLD" "THE POLAR WORLD" AND "THE SUBTERRANEAN WORLD"

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PREFACE

TO

THE THIRD AND FOURTH EDITIONS.

Nothing can be more agreeable to an author anxious to merit the suffrages of the public, than the opportunity afforded him, by a new edition, of correcting past errors or adding improvements to his work. Should any one of my readers think it worth his while to compare 'The Sea,' such as it now is, with what it formerly was, I have no doubt he will do me the justice to say that I have conscientiously striven to deserve his approbation.

Two new chapters—one on Marine Constructions, the other on Marine Caves—have been added; those on the Molluscs and Cœlenterata (Jelly-fishes, Polyps) almost entirely re-written; and those on Fishes, Crustaceans, Microscopic Animals, the Geographical Distribution of Marine Life, and the Phosphorescence of the Sea, considerably enlarged; not to mention a number of minor improvements dispersed throughout the volume.

Great attention has also been paid to the Illustrations, many of questionable value having been omitted in the present edition, to make room for a number of others,

which will be found of great use for the better understanding of the text.

In one word, I have done my best to raise my work to the standard of the actual state of science, and to render it, as far as my humble abilities go, a complete epitome of all that the *general* reader *cares* to know about the marvels of the deep.

G. HARTWIG.

SALON VILLAS, LUDWIGSBURG:
June 30, 1873.

PREFACE

TO

THE FIRST TWO EDITIONS.

FOR years my daily walks have been upon the beach, and I have learnt to love the ocean as the Swiss mountaineer loves his native Alps, or the Highlander the heath-covered hills of Caledonia. May these feelings have imparted some warmth to the following pages, and serve to render the reader more indulgent to their faults!

G. HARTWIG.

GÖTTINGEN: *July* 17, 1860.

CONTENTS.

PART I.

THE PHYSICAL GEOGRAPHY OF THE SEA.

CHAPTER I.

THE MAGNITUDE OF THE SEA.

Extent of the Ocean.—Length of its Coast-Line.—Mural, Rocky, and Flat Coasts. —How deep is the Sea?—Average Depth of the Atlantic Ocean.—The Telegraphic Plateau between Newfoundland and Ireland.—Measurement of Depth by the Rapidity of the Tide-Wave.—Progressive Changes in the Limits of the Ocean.—Alluvial Deposits.—Upheaving.—Subsidence.—Does the Level of the Sea remain unchanged, and is it everywhere the same?—Composition and Temperature of Sea-Water.—Its intrinsic Colour.—The Azure Grotto at Capri. —Modification of Colour owing to Animals and Plants.—Submarine Landscapes viewed through the Clear Waters . . . . . . Page 3

CHAPTER II.

THE WAVES OF THE OCEAN

Waves and the Mode of their Formation.—Height and Velocity of Storm-Waves, on the High Seas, according to the Calculations of Scoresby, Arago, Sir James Ross, and Wilkes.—Their Height and Power on Coasts.—Their Destructive Effects along the British Shore.—Dunwich.—Reculver.—Shakspeare's Cliff 24

CHAPTER III.

THE TIDES.

Description of the Phenomenon.—Devastation of Storm-Floods on Flat Coasts.—What did the Ancients know of the Tides?—Their Fundamental Causes revealed by Kepler and Newton.—Development of their Theory by La Place, Euler, and Whewell.—Vortices caused by the Tides.—The Maelstrom.—Charybdis.—The *Barre* at the mouth of the Seine.—The Euripus 32

CHAPTER IV.

MARINE CAVES.

Effects of the Sea on Rocky Shores.—Fingal's Cave.—Beautiful Lines of Sir Walter Scott.—The Antro di Nettuno.—The Cave of Hunga.—Legend of its Discovery.—Marine Fountains.—The Skerries.—The Souffleur in Mauritius.—The Buffadero on the Mexican Coast . . . . . . Page 45

CHAPTER V.

OCEAN CURRENTS.

Causes of the Oceanic Currents.—The Equatorial Stream.—The Gulf Stream.—Its Influence on the Climate of the West European Coasts.—The Cold Peruvian Stream.—The Japanese Stream 54

CHAPTER VI.

THE AËRIAL AND TERRESTRIAL MIGRATIONS OF THE WATERS.

Movements of the Waters through Evaporation.—Origin of Winds.—Trade-Winds.—Calms.—Monsoons.—Typhoons.—Tornadoes.—Water-Spouts.—The Formation of Atmospherical Precipitations.—Dew.—Its Origin.—Fog.—Clouds.—Rain.—Snow.—Hail.—Sources.—The Quantities of Water which the Rivers pour into the Ocean.—Glaciers and their Progress.—Icebergs.—Erratic Blocks.—Influence of Forests on the Formation and Retention of Atmospherical Precipitations.—Consequences of their excessive Destruction.—The Power of Man over Climate.—How has it been used as yet? 65

CHAPTER VII.

MARINE CONSTRUCTIONS.

Lighthouses.—The Eddystone.—Winstanley's Lighthouse, 1696.—The Storm of 1703.—Rudyerd's Lighthouse destroyed by Fire in 1755.—Singular Death of one of the Lighthouse Men.—Anecdote of Louis XIV.—Smeaton.—Bell Rock Lighthouse.—History of the Erection of Skerryvore Lighthouse.—Illumination of Lighthouses.—The Breakwater at Cherbourg.—Liverpool Docks.—The Tubular Bridge over the Menai Straits.—The Sub-oceanic Mine of Botallack. 80

PART II.

THE INHABITANTS OF THE SEA.

CHAPTER VIII.

THE CETACEANS.

General Remarks on the Organisation of the Cetaceans.—The Large Greenland Whale.—His Food and Enemies.—The Fin-Back or Rorqual.—The Antarctic Whale.—The Sperm Whale.—The Unicorn Fish.—The Dolphin.—Truth and Fable.—The Porpoise.—The Grampus.—History of the Whale Fishery . 95

CHAPTER IX.

SEALS AND WALRUSES.

The Manatees and the Dugongs.—The Seals and the Esquimaux.—King Menelaus in a Seal's Skin.—Barbarous Persecutions of the Seals in Behring's Sea and the Pacific.—Adventures of a Sealer from Geneva.—The Sea Calf.—The Sea Bear.—His Parental Affection.—The Sea Lions.—The Sea Elephant.—The Arctic Walrus.—The Boats of the "Trent" fighting with a Herd of Walruses.—The White Bear.—Touching Example of its Love for its Young.—Chase of the Sea Otter . . . . Page 117

CHAPTER X.

SEA-BIRDS.

Their Vast Numbers.—Strand-Birds.—Artifices of the Sea-Lark to protect its Young.—Migrations of the Strand-Birds.—The Sea-Birds in General.—The Anatidæ.—The Eider Duck.—The Sheldrake.—The Loggerheaded Duck.—Auks and Penguins.—The Cormorant.—Its Use by the Chinese for Fish-catching.—The Frigate Bird.—The Soland Goose.—The Gulls.—The Petrels.—The Albatross.—Bird-catching on St. Kilda.—The Guano of the Chincha Islands 142

CHAPTER XI.

THE REPTILES OF THE OCEAN.

The Saurians of the Past Seas.—The Anatomical Structure of the Turtles.—Their Size.—Their Visits to the Shores.—The Dangers that await their Young.—Turtles on the Brazilian Coast.—Prince Maximilian of Neuwied and the Turtle.—Conflicts of the Turtles with Wild Dogs and Tigers on the Coast of Java.—Turtle-catching on Ascension Island.—Tortoise-shell.—The Amblyrhynchus cristatus.—Marine Snakes.—The Great Sea-Snake . . 172

CHAPTER XII.

THE MARINE FISHES.

General Observations on Fishes.—Their Locomotive Organs—Tail—Fins.—Classification of Fishes by Cuvier.—Air-Bladder.—Scales.—Beauty of the Tropical Fishes.—The Gills.—Terrestrial Voyages of the Anabas and the Hassar.—Examples of Parental Affection.—Organs of Sense.—Offensive Weapons of Fishes.—The Sea-Wolf.—The Shark.—The Saw-Fish.—The Sword-Fish.—The Torpedo.—The Star-Gazer.—The Angler.—The Chætodon Rostratus.—The Remora, used for catching Turtles.—Defensive Weapons of Fishes.—The Weever.—The Stickleback.—The Sun-Fish.—The Flying-Fish.—The numerous Enemies of the Fishes.—Importance and History of the Herring Fishery.—The Pilchard.—The Sprat.—The Anchovy.—The Cod.—The Stur-

geons.—The Salmon.—The Tunny.—The Mackerel Family.—The Eel.—The Murey.—The Conger.—The Sand-Launce.—The Plectognaths.—The Sea-Horse.—The Pipe-Fish.—The Flat-Fishes.—The Rays.—The Fecundity of Fishes . . . . Page 186

CHAPTER XIII.

CRUSTACEA.

CRABS—LOBSTERS.

How are they distinguished from the Insects?—Barnacles and Acorn-shells.—Siphonostomata.—Entomostraca.—King-Crab.—Edriophthalmia.—Sandhoppers.—Thoracostraca.—Compound Eye of the higher Crustaceans.—Respiratory Apparatus of the Decapods.—Digestive Organs.—Chelæ or Pincers.—Distribution of Crabs.—Land Crabs.—The Calling Crab.—Modifications of the Legs in different species.—The Pinna and Pinnotheres.—Hermit Crabs.—The Lobster.—The Cocoa-nut Crab.—The Shrimp.—Moulting Process.—Metamorphoses of Crabs.—Victims and Enemies of the Crustaceans.—Their Fecundity.—Marine Spiders and Insects 243

CHAPTER XIV.

MARINE ANNELIDES.

The Annelides in general.—The Eunice sanguinea.—Beauty of the Marine Annelides.—The Giant Nemertes.—The Food and Enemies of the Annelides.—The Tubicole Annelides.—The Rotifera.—Their Wonderful Organisation.—The Synchæta Baltica 262

CHAPTER XV.

MOLLUSCS.

The Molluscs in general.—The Cephalopods.—Dibranchiates and Tetrabranchiates—Arms and Tentacles.—Suckers.—Hooked Acetabula of the Onychoteuthis.—Mandibles.—Ink Bag.—Numbers of the Cephalopods—Their Habits—Their Enemies—Their Use to Man—Their Eggs.—Enormous size of several species.—The fabulous Kraken.—The Argonaut.—The Nautili.—The Cephalopods of the Primitive Ocean.—The Gasteropods.—Their Subdivisions.—Gills of the Nudibranchiates.—The Pleurobranchus plumula.—The Sea-Hare.—The Chitons.—The Patellæ.—The Haliotis or Sea-Ear.—The Carinariæ.—The Pectinibranchiates.—Variety and Beauty of their Shells.—Their Mode of Locomotion.—Foot of the Tornatella and Cyclostoma.—The Ianthinæ.—Sedentary Gasteropods.—The Magilus.—Proboscis of the Whelk.—Tongue of the Limpet.—Stomach of the Bulla, the Scyllæa, and the Sea-Hare.—Organs of Sense in the Gasteropods—Their Caution—Their Enemies—Their Defences—Their Use to Man.—Shell-Cameos.—The Pteropods—Their Organisation and Mode of Life.—The Butterflies of the Ocean.—The Lamellibranchiate Acephala—Their Organisation.—Siphons.—The Pholades.—Foot of the Lamellibranchiates.—The Razor-Shells.—The Byssus of the Pinnæ.—Defences of the Bivalves—Their Enemies.—The common Mussel.—Mussel Gardens.—The Oyster.—Oyster Parks.—Oyster Rearing in the Lago di Fusaro.—Formation of new

Oyster Banks.—Pearl-fishing in Ceylon.—How are Pearls formed?—The Tridacna gigas.—The Teredo navalis.—The Brachiopods.—The Terebratulæ.—The Polyzoa.—The Sea-Mats.—The Escharæ.—The Lepraliæ.—Bird's Head Processes.—The Tunicata.—The Sea-Squirts.—The Chelyosoma.—The Botrylli.—The Pyrosomes.—The Salpæ.—Interesting Points in the Organisation of the Tunicata . . . . Page 270

CHAPTER XVI.

ECHINODERMATA.

STAR-FISHES, SEA-URCHINS, AND SEA-CUCUMBERS.

The Star-Fishes—Their Feet or Suckers.—Voracity of the Asterias.—The Rosy Feather-Star.—Brittle and Sand-Stars.—The real Sea-Stars of the British Waters.—The Sea-Urchins.—The Pedicellariæ.—The Shell and the Dental Apparatus of the Sea-Urchins.—The Sea-Cucumbers.—Their strange Dismemberments.—Trepang-fishing on the Coast of North Australia.—In the Feejee Islands 328

CHAPTER XVII

CŒLENTERATA.

POLYPS AND JELLY-FISHES.

Thread-cells or Urticating Organs.—Sertulariæ.—Campanulariadæ.—Hydrozoic Acalephæ.—Medusidæ.—Lucernariadæ.—Calycophoridæ.—The Velella.—The Portuguese Man-of-war.—Anecdote of a Prussian Sailor.—Alternating Fixed and Free-swimming Generations of Hydrozoa.—Actinozoa.—Ctenophora.—Their Beautiful Construction.—Sea-anemones.—Dead Man's Toes.—Sea-pens.—Sea-rods.—Red Coral.—Coral Fishery.—Isis hippuris.—Tropical Lithophytes.—History of the Coral Islands—Darwin's Theory of their Formation—The progress of their Growth above the level of the Sea 345

CHAPTER XVIII.

PROTOZOA.

The Foraminifera.—The Amœbæ.—Their Wonderful Simplicity of Structure.—The Polycystina.—Marine Infusoria.—Sponges.—Their Pores—Fibres and Spiculæ—The Common Sponge of Commerce 378

CHAPTER XIX.

MARINE PLANTS.

The Algæ.—Zostera marina.—The Ulvæ and Enteromorphæ.—The Fuci.—The Laminariæ.—Macrocystis pyrifera.—Description of the Submarine Thickets at Tierra del Fuego.—Nereocystis lutkeana.—The Sargasso Sea.—The Gathering of edible Birds'-nests in the marine Caves of Java.—Agar-Agar.—The Florideæ.—The Diatomaceæ.—Their importance in the economy of the Seas . 390

CHAPTER XX.

THE GEOGRAPHICAL DISTRIBUTION OF MARINE LIFE.

The Dependence of all created Beings upon Space and Time.—The Influences which regulate the Distribution of Marine Life.—The four Bathymetrical Zones of Marine Life on the British Coasts, according to the late Professor Edward Forbes of Edinburgh.—Abyssal Animals.—*Bathybius Haeckelii.*—Deep-Sea Sponges and Shell-Fish.—Vivid Phosphorescence of Deep-Sea Animals.—Deep-Sea Shark Fishery.—The "Challenger." . . . . . Page 405

CHAPTER XXI.

THE PHOSPHORESCENCE OF THE SEA.

Its Causes.—Noctiluca miliaris.—Phosphorescent Annelides and Beroës.—Intense Phosphorescence of the Pyrosoma atlantica.—Luminous Pholades.—The luminous Shark.—Phosphorescent Algæ.—Citations from Byron, Coleridge, Crabbe, and Scott 423

CHAPTER XXII.

THE PRIMITIVE OCEAN.

The Giant-Book of the Earth-rind.—The Sea of Fire.—Formation of a solid Earth-crust by cooling.—The Primitive Waters.—First awakening of Life in the Bosom of the Ocean.—The Reign of the Saurians.—The future Ocean 433

PART III.

THE PROGRESS OF MARITIME DISCOVERY.

CHAPTER XXIII.

Maritime Discoveries of the Phœnicians.—Expedition of Hanno.—Circumnavigation of Africa under the Pharaoh Necho.—Colæus of Samos.—Pytheas of Massilia.—Expedition of Nearchus.—Circumnavigation of Hindostan under the Ptolemies.—Voyages of Discovery of the Romans.—Consequences of the Fall of the Roman Empire.—Amalfi.—Pisa.—Venice.—Genoa.—Resumption of Maritime Intercourse between the Mediterranean and the Atlantic.—Discovery of the Mariner's Compass.—Marco Polo. 443

CHAPTER XXIV.

Prince Henry of Portugal.—Discovery of Porto Santo and Madeira.—Doubling of Cape Bojador.—Discovery of the Cape Verde Islands.—Bartholomew Diaz.—Vasco de Gama.—Columbus.—His Predecessors.—Discovery of Greenland by

Günnbjorn.—Bjorne Herjulfson.—Leif.—John Vaz Cortereal.—John and Sebastian Cabot.—Retrospective View of the Beginnings of English Navigation.—Ojeda and Amerigo Vespucci.—Vincent Yañez Pinson.—Cortez.—Verazzani.—Cartier.—The Portuguese in the Indian Ocean . . . Page 454

CHAPTER XXV.

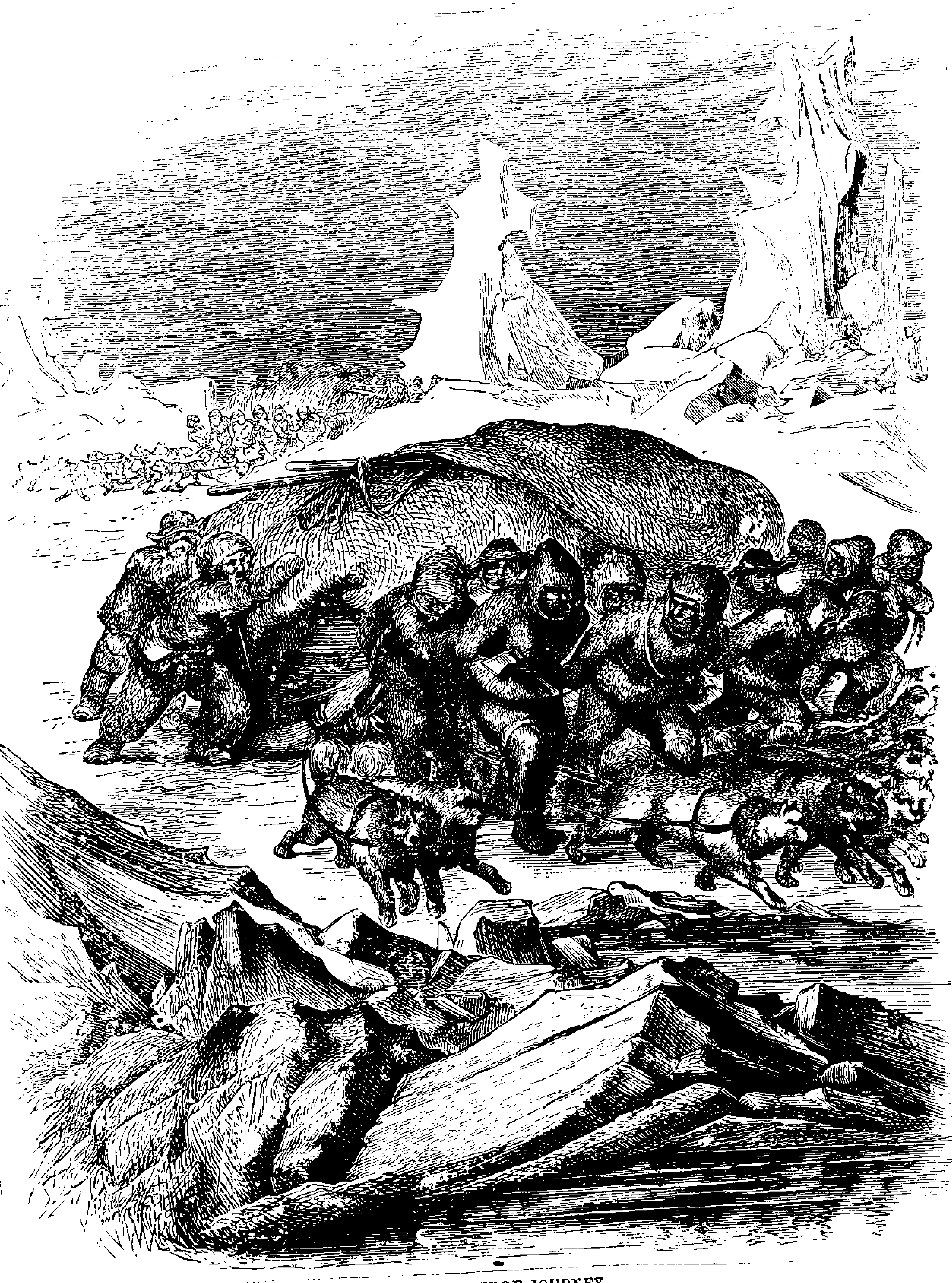
Vasco Nuñez de Balboa.—His Discovery of the Pacific, and subsequent Fate.—Ferdinand Magellan.—Sebastian el Cano, the first Circumnavigator of the Globe.—Discoveries of Pizarro and Cortez.—Urdaneta.—Juan Fernandez.—Mendoza.—Drake.—Discoveries of the Portuguese and Dutch in the Western Pacific.—Attempts of the Dutch and English to discover North-East and North-West Passages to India.—Sir Hugh Willoughby and Chancellor.—Frobisher.—Davis.—Barentz.—His Wintering in Nova Zembla.—Quiros.—Torres.—Schouten.—Le Maire.—Abel Tasman.—Hudson.—Baffin.—Dampier.—Anson.—Byron.—Wallis and Carteret.—Bougainville 464

CHAPTER XXVI.

What had Cook's Predecessors left him to discover?—His first Voyage.—Discovery of the Society Islands, and of the East Coast of New Holland.—His second Voyage.—Discovery of the Hervey Group.—Researches in the South Sea.—The New Hebrides.—Discovery of New Caledonia and of South Georgia.—His third Voyage.—The Sandwich Islands.—New Albion.—West Georgia.—Cook's Murder.—Vancouver.—La Peyrouse 485

CHAPTER XXVII.

Scoresby.—The Arctic Navigators.—Ross.—Parry.—Sufferings of Franklin and his Companions on his Overland Expedition in 1821.—Parry's Sledge-journey to the North Pole.—Sir John Franklin.—M'Clure.—Kane.—M'Clintock.—South Polar Expeditions.—Bellinghausen.—Weddell.—Biscoe.—Balleny.—Dumont d'Urville.—Wilkes.—Sir James Ross.—Recent Scientific Voyages of Circumnavigation 496



ARCTIC SLEDGE-JOURNEY.

Description of the Frontispiece.

ARCTIC SLEDGE-JOURNEY.

The sledge plays a very conspicuous part in the history of arctic discovery, as it enables the bold investigators of the icy wildernesses of the North to penetrate to many places, impervious to navigation, to establish dépôts of provisions for future emergencies, or even becomes the means of saving their lives when their ship has been lost or hopelessly blocked up. Whenever dogs can be had, these useful animals are made use of for the transport. Our plate represents one of these sledging parties threading its way through blocks of ice, and gives a good idea of the difficulties they have to encounter.

(BLANK PAGE-NO CONTENTS)

LIST OF ILLUSTRATIONS.

PLATES.

Arctic Sledge-Journey . . *Frontispiece.*

	FACING PAGE
The Souffleur Rock, Mauritius	52
Lighthouse and Waterspout	65
Australian Sea-Bears	117
The Boats of H.M.S. "Trent" attacked by Walruses	131
Penguins	142
Subaqueous Life—Sticklebacks and Nest	195
Russian Official collecting Algæ	392

MAP.

Map of the Globe, showing the direction of the Ocean Currents, Cotidal Lines, &c. *facing page* 3.

WOODCUTS.

	PAGE
Annelidans:—	
Aphrodita, or Sea-Mouse	264
Nereis	263
Serpula, attached to a Shell	266
Beachy Head	5
Bell Rock Lighthouse	86
Birds:—	
Albatross, Wandering	163
Auk	168
Great	151
Avoset	146
Barnacle Goose	146
Cormorant, common	155
Curlew	143
Eider Duck	146
Flamingo	142
Gannet, common	156
Birds—*continued*:	
Great Crested Grebe	150
Guillemot, Black	165
(winter plumage)	167
Herring Gulls	158
Hooded Merganser	404
Pelican	116, 154
Penguins	152
Petrel, Broad-billed	160
Fork-tailed	160
Stormy	162
Plover	144
Puffins	165, 167
Red-breasted Merganser	149
Scissor-bill (Rhynchops nigra)	144
Sheldrake	148
Skimmer, Black	169

PAGE

Birds—*continued*:
- Snow Goose 146
- Speckled Diver 145
- Tailor-bird 143

Birds of Passage 171
Bones of the Anterior Fin of a Whale 96
Cœlenterata.—
- Alcyonidium elegans . . 363
- Astræa 373
- Caryophyllia 370
- Chrysaora hysoscella . . 357
- Coryniadæ 358
- Ctenophora 360
- Diphyes appendiculata . 353
- Grey Sea-Pen 365
- Isis hippuris 369
- Jelly Fishes . 349, 350, 351
- Lucernalia auricula . . . 352
- Medusæ . . 349, 350, 351
- Physalia caravella . . . 355
- Physophora Philippii . . 356
- Red Coral 367
- Sertularia tricuspidata . 347
- Stone Corals . . 373, 374
- Tubipora Musica 370
- Velella 354
- Virgularia mirabilis . . 365
- Vogtia pentacantha . . 353

Compound Foraminiferous Protozoon, magnified . . 380
Crustaceans:—
- American Sand-Crab . . 252
- Balanus ovularis, and group of 244
- Barnacle 101 244
- Calling-Crab of Ceylon 251
- Chelura tenebrans . . 247
- Diogenes Hermit-Crab . 254
- Dromia vulgaris . . . 249
- Jamaica Land-Crab . . 250
- King Crab 246
- Large-clawed Calling-Crab . 250
- Limnoria lignorum . . . 247
- Metamorphosis of Carcinus Mœnas 258
- Pea-Crab 253
- Phyllosoma 258
- Pinna Augustana . . . 253
- Sandhopper 246
- Scyllarus equinoxialis . . 248
  - square facets of . . 247
- Spotted Fin-Crab . . 252

PAGE

Crustaceans—*continued*:
- Spotted Mantis-Crab . . 256
- Stenopus hispidus . . 261
- Whale-Louse 101

Crustaceans and Oysters . . 256
Dental Apparatus of the Sea-Urchin, viewed from above . 339
Ear, Human 196
Ear of the Perch 196
Echinodermata:—
- Cross-Fish, common . . 334
- Eatable Trepang . . . 340
- Goniaster 336
- Lily-Encrinite 330
- Sand-Star 332
- Sea-Urchin 337
  - Edible 338
  - Mammillated . . 338
- Warted Euryale 333

Eddystone Lighthouse . . 84
Esquimaux in his Kayak . . 120
Fingal's Cave 47
Fishes:—
- Ammodyte, or Launce . . 230
- Anabas of the dry tanks . 192
- Anchovy 214
- Angler 203
- Bonito 223
- Cod 215
- Conger Eel 228
- Diodon 205
- Dory 242
- Electric Eel 202
- European Sly 203
- Fierasfer 340
- File-Fish 232
- Flounder 238
- Flying Fish 158, 206, 224
- Frog-Fish 192
- Gar-Fish 223
- Globe-Fish 232
- Gurnard 197, 414
- Haddock 215
- Halibut 236
- Herring 101, 208
- Lamprey 231
- Ling 215
- Mackerel 222
- Mullet, Grey 415
  - Red . . . 197, 415
- Myxine 231
- Perch, internal ear of the . 196

	PAGE
Fishes—continued:	
Picked Dog-Fish	200
Pilchard	212
Pilot-Fish	225
Plaice	238
Porcupine-Fish	232
Salmo Rossii	220
Salmon	415
Sand-Eel	415
Saw-Fish	201
Sea-Horse	234, 344
Shark, Blue	200
Hammer-headed	199
White	198
Short Sun-Fish	232, 422
Sole	237
portion of skin of, highly magnified	190
Sturgeon, common	217
Surgeon-Fish	205
Swimming Pegasus	207
Sword-Fish	99, 201
Thornback	240
Torpedo	201
Toxotes Jaculator	203
Trunk-Fish	232
Tunny	221
Turbot	237
Wolf-Fish	197
Foraminifera, various forms of	381
Fossils:—	
Ammonite	437
Belemnite	437
Ichthyosaurus communis	172, 438
Pentacrinus Briareus, portion of	330
Plesiosaurus	438
Trilobite	436
Hill at the Rapid on Bear Lake River (North-West Territory, North America)	23
H. M.S. "Resolute" lying to in the North Atlantic	24
Ice-Bear approaching the "Dorothea" and "Trent"	137
Japan Junks	63
Licmophora flabellata	403
Mammals:—	
Dolphin	107
Dugong	117
female, of Ceylon	119
Manatee	117
Mammals—continued:	
Polar Bear (Ursus maritimus)	134
Porpoise	108
Rorqual	101
Sea-Otter	140
Seal	119, 123, 135
Greenland	123
Walrus	129, 135
Whale, common	97
Whale, Spermaceti	102, 115
Mollusks:—	
Argonaut	280
Ascidia mammillata	322
Banded Dipper	141
Bivalve deprived of its shell, to show its various openings	300
Botryllus	324
Bulla	294
Calamary	272
Carinaria	287
Cellularia	319
Chelyosoma Macleayanum	323, 327
Chinese Wentle-trap (Scalaria pretiosa)	289
Chiton squamosus	285
Clavellina producta	322
Clio borealis	98
Cockle, common	303, 306
Cuttle-Fish (Sepia)	104, 275
Diazona violacea	324
Donax	301
Edible Mussel	307
Edible Oyster	308
Eolis	284
Eschara cervicornis	318
Gorgeous Doris	235
Haliotis	287
Harp-shell	288
Hippopus maculatus	315
Ianthina communis	290
Leaf-like Sea-mat	316, 317
Limpet and Shell	286, 292, 411
Magilus antiquus	291
Mitre-shells	288
Murex haustellum	291, 296
Oliva hispidula	290
Onychoteuthis	274
Orange Cone-shell	288
Pearl-Oyster	312
Pearly Nautilus	280
Periwinkle	411

	PAGE
Mollusks—*continued*:	
Petunculus	302
Pholas striata	302
Pinna	305
Poulp (Octopus)	272, 273
Pteroceras scorpio	290
Retepora cellularis	318
Salpa	326
Scyllæa	283
Sea-Hare, compound stomach of	295
Sepia	104, 275
Solen, or Razor-Shell	304
Strombus pes pelicani	290
Syllæa, gizzard of	294
Tiara	283
Tridacna gigas	314
Whelk	413
Worm-shell	291
Muscles and Electric Batteries of the Torpedo	202
Nervous Axis of an Annelidan	262
Noctiluca miliaris	419
Ova of the Cuttle-Fish	278
Protozoa:—	
Amœba	379
Foraminifera	381
Halina papillaris	386
Infusoria, marine	384
Nummulina discoidalis	378
Polycistina	383
Sponges	385
Tethea	385, 386
Reptiles:—	
Alligator Lucius	173
Reptiles—*continued*:	
Tortoise	174
Turtle, Green	170
Hawk's Bill	180
Loggerhead	176
Water-Snake	183
Rocky Mountains at the bend of the Bear Lake River	79
Rotifera:—	
Conochilus volvox	268
Philodina roseola	269
Ptygura melicerta	267
Saw of the Saw-Fish	100
Sea-Fowl Shooting	168
Skeleton of the Dugong	118
of the Perch	188
of the Seal	119
of the Tortoise	174
Skerryvore Lighthouse	89
Skull and Head of Walrus	129
Skull of Whale, with the Baleen	98
Surirella constricta	402
Theoretic representation of the Circulation in Fishes	192
Theoretic representation of the Circulation in Mammals and Birds	175
Theoretic representation of the Circulation in Reptiles	175
Torso Rock, near Point Deas Thomson, in the Arctic Ocean	9
Sockets with teeth, of Echinus esculentus	339
Urticating organs of Cœlenterata	346
Water-Spouts	69, 70

PART I.

THE

PHYSICAL GEOGRAPHY OF THE SEA.

CHAPTER I.

THE MAGNITUDE OF THE SEA.

Extent of the Ocean.—Length of its Coast-Line.—Mural, Rocky, and Flat Coasts. —How deep is the Sea?—Average Depth of the Atlantic Ocean.—The Telegraphic Plateau between Newfoundland and Ireland.—Measurement of Depth by the Rapidity of the Tide-Wave.—Progressive Changes in the Limits of the Ocean.—Alluvial Deposits.—Upheaving.—Subsidence.—Does the Level of the Sea remain unchanged, and is it everywhere the same?—Composition and Temperature of Sea-Water.—Its intrinsic Colour.—The Azure Grotto at Capri. —Modification of Colour owing to Animals and Plants.—Submarine Landscapes viewed through the Clear Waters.

Of all the gods that divide the empire of the earth, Neptune rules over the widest realms. If a giant-hand were to uproot the Andes and cast them into the sea, they would be engulphed in the abyss, and scarcely raise the general level of the waters.

The South American Pampas, bounded on the north by ropical palm-trees, and on the south by wintry firs, are no oubt of magnificent dimensions, yet these vast deserts seem significant when compared with the boundless plains of earth-e circling ocean. Nay! a whole continent, even America or sia, appears small against the immensity of the sea, which vers with its rolling waves nearly three-fourths of the entire s rface of the globe.

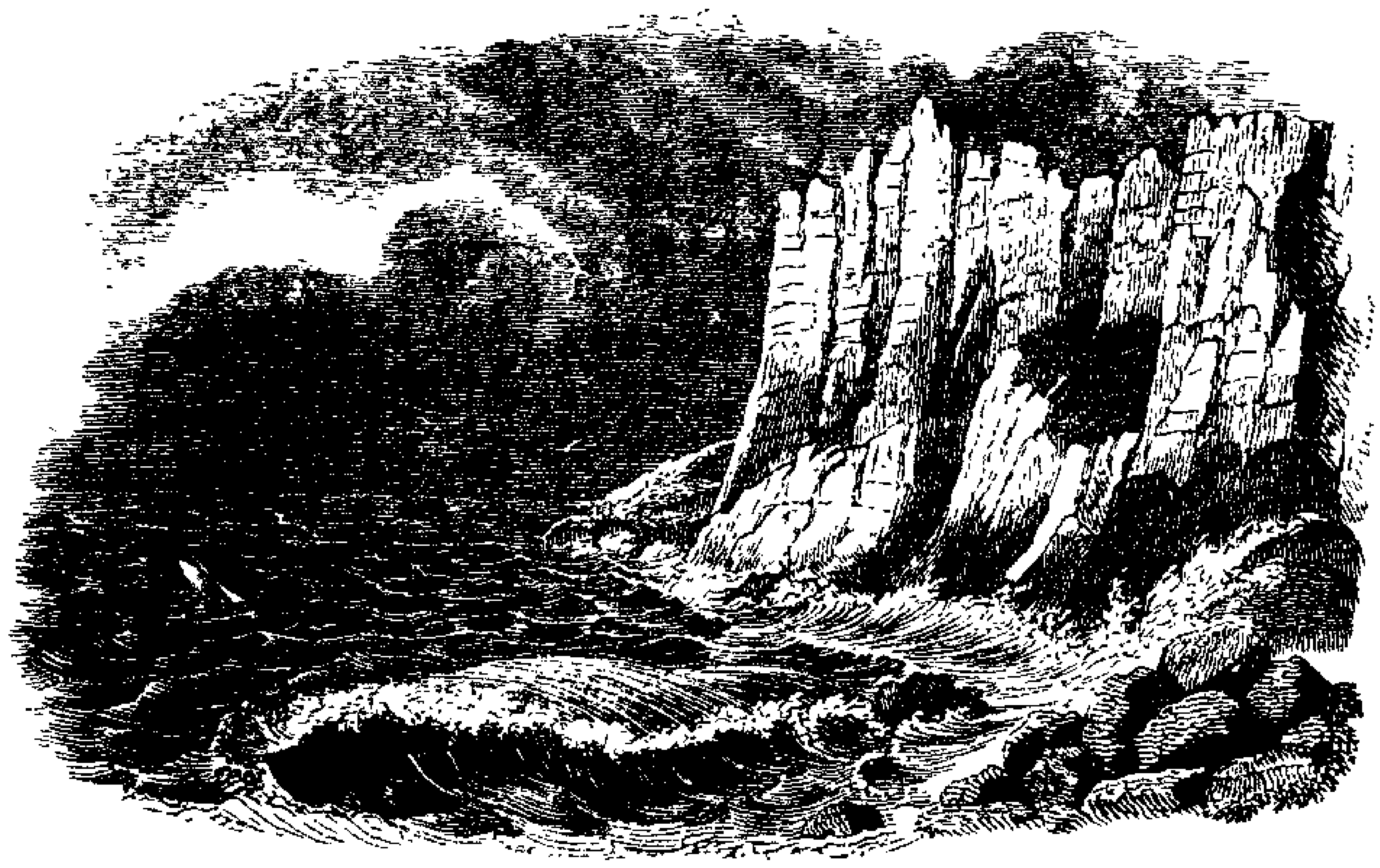
A single glance over the map shows us at once how very unually water and land are distributed. In one part we see ntinents and islands closely grouped together, while in another e sea widely spreads in one unbroken plain; here vast peninlas stretch far away into the domains of ocean, while there mmense gulfs plunge deeply into the bosom of the land. At rst sight it might appear as if blind chance had presided over his distribution, but a nearer view convinces us that providen-

tial laws have established the existing relations between the solid and fluid surfaces of the earth. If the sea had been much smaller, or if the greatest mass of land had been concentrated in the tropical zone, all the meteorological phenomena on which the existence of actual organic life depends would have been so different, that it is *doubtful* whether man could then have existed, and *certain* that, under those altered circumstances, he never would have attained his present state of civilisation. The dependence of our intellectual development upon the existing configuration of the earth, convinces us that Divine wisdom and not chaotic anarchy has from all eternity presided over the destinies of our planet.

The length of all the coasts which form the boundary between sea and land can only be roughly estimated, for who has accurately measured the numberless windings of so many shores? The entire coast line of deeply indented Europe and her larger isles measures about 21,600 miles, equal to the circumference of the earth; while the shores of compact Africa extend to a length of only 14,000 miles. I need hardly point out how greatly Europe's irregular outlines have contributed to the early development of her superior civilisation and political predominance. The coasts of America measure about 45,000 miles, those of Asia 40,000, while those of Australia and Polynesia may safely be estimated at 16,000. Thus the entire coast-line of the globe amounts to about 136,000 miles, which it would take the best pedestrian full twenty-five years to traverse from end to end.

How different is the aspect of these shores along which the ever-restless sea continually rises or falls! Here steep rock-walls tower up from the deep, while there a low sandy beach extends its flat profile as far as the eye can reach. While some coasts are scorched by the vertical sunbeam, others are perpetually blocked up with ice. Here the safe harbour bids welcome to the weather-beaten sailor, the light-house greets him from afar with friendly ray; the experienced pilot hastens to guide him to the port, and all along the smiling margin of the land rise the peaceful dwellings of civilised man. There, on the contrary, the roaring breakers burst upon the shore of some dreary wilderness, the domain of the savage or the brute. What a wonderful variety of scenes unrolls itself before our fancy as it

roams along the coasts of ocean from zone to zone! what changes, as it wanders from the palm-girt coral island of the



Beecny Head.

tropical seas to the melancholy strands where, verging towards the poles, all vegetable life expires! and how magnificently grand does the idea of ocean swell out in our imagination, when we consider that its various shores witness at one and the same time the rising and the setting of the sun, the darkness of night and the full blaze of day, the rigour of winter and the smiling cheerfulness of spring!

The different formation of sea-coasts has necessarily a great influence on commercial intercourse. Bold mural coasts, rising precipitously from the deep sea, generally possess the best harbours. Rocky shores also afford many good ports, but most frequently only for smaller vessels, and of difficult access, on account of the many isolated cliffs and reefs which characterise this species of coast formation.

In places where high lands reach down to the coast, the immediate depth of the sea is proportionably great; but wherever the surface rises gently landwards, the sea-bed continues with a corresponding slope downwards. On these flat coasts the tides roll over a sandy or shingly beach; and here the aid of human industry is frequently required to create artificial ports, or to prevent those already existing from being choked with sand.

On many flat coasts the drift-sand has raised *dunes,* wearying

the eye by their monotonous uniformity; on others, where these natural bulwarks are wanting, artificial embankments, or dykes protect the lowlands against the encroachments of the sea, or else the latter forms vast salt-marshes and lagunes. On some coasts these submerged or half-drowned lands have been transformed by the industry of man into fertile meadows and fields, of which the Dutch Netherlands afford the most celebrated example; while in other countries, such as Egypt, large tracts of land once cultivated have been lost to the sea, in consequence of long misrule and tyranny.

How deep is the sea? How is its bottom formed? Does life still exist in its abyssal depths? These mysteries of ocean, which no doubt floated indistinctly before the mind of many an inquisitive mariner and philosopher of ancient times, have only recently been subjected to a more accurate investigation. Their solution is of the highest importance, both to the physical geographer, whose knowledge must necessarily remain incomplete until he can fully trace the deep-sea path of oceanic currents, and to the zoologist, to whom it affords a wider insight into the laws which govern the development of the innumerable forms of life with which our globe is peopled.

The ordinary system of sounding by means of a weight attached to a graduated line, and "armed" at its lower end with a thick coating of soft tallow, so as to bring up evidence of its having reached the bottom in a sample of mud, shells, sand, gravel, or ooze, answers perfectly well for comparatively shallow water, and for the ordinary purposes of navigation, but it breaks down for depths much over 1000 fathoms. The weight is not sufficient to carry the line rapidly and vertically to the bottom; and if a heavier weight be used, ordinary sounding line is unable to draw up its own weight along with that of the lead from great depths, and gives way, so that by this means no information can be gained as to the nature of the sea-bottom. To obviate this difficulty, several ingenious instruments have been invented, such as the "Bull-dog" sounding machine, which is so contrived that on touching the bottom the weight becomes detached, while at the same time a pair of scoops, closing upon one another scissorwise on a hinge, and permanently attached

to the sounding-line, retain and are able to bring up a sample of the bottom.

With the aid of steam, dredging has also been successfully carried down to 2,435 fathoms, so that the ocean bed may become in time as well known to us as the bed of the Mersey or the Thames.

Both sounding and dredging at great depths are, however, difficult and laborious tasks, which can only be performed under very favourable circumstances, and require a vessel specially fitted at considerable expense.

Many of the early deep soundings in the Atlantic, which reported the astonishing depths of 46,000 or even 50,000 feet, are now known to have been greatly exaggerated. In some cases bights of the line seem to be carried along by submarine currents, and in others it is found that the line has been running out by its own weight only, and coiling itself in a tangled mass directly over the lead. These sources of error vitiate very deep soundings; and consequently, in the last chart of the North Atlantic, published on the authority of Rear-Admiral Richards in November 1870, none are entered beyond 4000 fathoms, and very few beyond 3000.

"The general result," says Professor Wyville Thomson,* "to which we are led by the careful and systematic deep-sea soundings which have been undertaken of late years is that the depth of the sea is not so great as was at one time supposed, and does not appear to average more than 2000 fathoms (12,000 feet), about equal to the mean height of the elevated table-lands of Asia.

"The thin shell of water which covers so much of the face of the earth occupies all the broad general depressions in its crust, and it is only limited by the more abrupt prominences which project above its surface, as masses of land with their crowning plateaux and mountain ranges. The Atlantic Ocean covers 30,000,000 of square miles, and the Arctic Sea 3,000,000, and taken together they almost exactly equal the united areas of Europe, Asia, and Africa—the whole of the Old World—and yet there seem to be few depressions on its bed to a greater depth than 15,000 or 20,000 feet—a little more than the height of Mont Blanc; and, except in the neighbourhood of the shores,

* "The Depths of the Sea," p. 228.

there is only one very marked mass of mountains, the volcanic group of the Açores."

Accurate soundings are as yet much too distant to justify a detailed description of the bed of the Atlantic. I will merely state that after sloping gradually to a depth of 500 fathoms to the westward of the coast of Ireland, in lat. 52° N., the bottom suddenly dips to 1700 fathoms, at the rate of from about 15 to 19 feet in the 100. From this point to within about 200 miles of the coast of Newfoundland, where it begins to shoal again, there is a vast undulating plain averaging about 2000 fathoms in depth below the surface—the "telegraph plateau' on which now rest the cables through which the electric power transmits its marvellous messages from one world to another.

Our information about the beds of the Indian, the Antarctic, and the Pacific Oceans is still more incomplete, but the few trustworthy observations which have hitherto been made seem to indicate that neither the depth nor the nature of the bottom of these seas differs greatly from what we find nearer home.

The inclosed and landlocked European seas are very shallow when compared with the high ocean: the Mediterranean, however, has in some parts a depth of more than 6000 feet; and even in the Black Sea, the plummet sometimes descends to more than 3000 feet; while the waters of the Adriatic everywhere roll over a shallow bed.

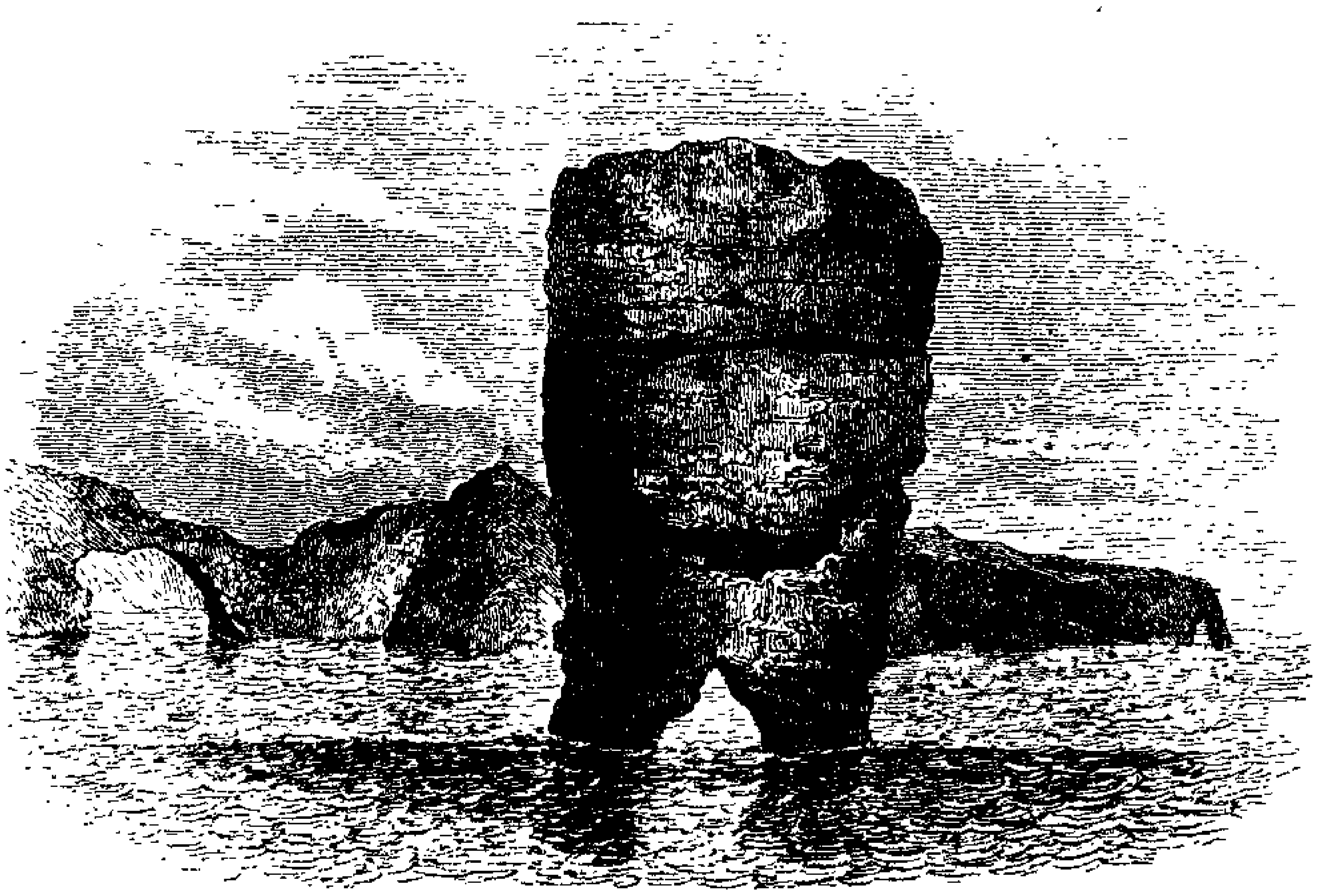
The researches of Mr. Russell on the swiftness of the tide-wave, showing that the rapidity of its progress increases with the depth of the waters over which it passes, afford us another means, besides the sounding line, of determining approximately the distance of the sea-bottom from its surface. According to this method, the depth of the Channel between Plymouth and Boulogne has been calculated at 180 feet; and the enormous rapidity of the flood wave over the great open seas (300 miles an hour and more) gives us for the mean depth of the Atlantic 14,400 feet, and for that of the Pacific 19,500.

Natural philosophers have endeavoured to calculate the quantity of the waters contained within the vast bosom of the ocean; but as we are still very far from accurately knowing the mean depth of the sea, such estimates are evidently based upon a very unsubstantial foundation.

So much at least is certain, that the volume of the waters of

the ocean as much surpasses all conception, as the number of their inhabitants, or of the sands that line their shores.

The boundaries of the ocean are not invariable; while in some parts it encroaches upon the land, in others it retreats from the expanding coast. In many places we find the sea perpetually gnawing and undermining cliffs and rocks; and



Torso Rock, near Point Deas Thomson, in the Arctic Ocean.

sometimes swelling with sudden rage, it devours a broad expanse of plain, and changes fertile meads into a dreary waste of waters. The Goodwin Sands, notorious for the loss of many a noble vessel, were once a large tract of low ground belonging to Earl Goodwin, father of Harold, the last of our Saxon kings; and being afterwards enjoyed by the monastery of St. Augustine at Canterbury, the whole surface was drowned by the abbot's neglect to repair the wall which defended it from the sea. In spite of the endeavours of the Dutch to protect their flat land by dykes against the inundatory waters, the storm-flood has more than once burst through these artificial boundaries, and converted large districts into inland seas.

But the spaces which in this manner the dry land has gradually or suddenly lost, or still loses, to the chafing ocean are largely compensated for in other places, by the vast accumulations

of mud and sand, which so many rivers continually carry along with them into the sea. Thus at the mouths of the Nile, of the Ganges, and of the Mississippi, large alluvial plains have been deposited, which now form some of the most fruitful portions of the globe. The whole Delta of Egypt, Bengal, and Louisiana, have thus gradually emerged from the waters.

The volcanic powers, which once caused the highest mountain chains to rise from the glowing bosom of the earth, are still uninterruptedly active in changing its surface, and are gradually displacing the present boundaries of sea and land, upheaving some parts and causing others to subside.

On the coast of Sweden, it has been ascertained that iron rings fixed to rocks which formerly served for the fastening of boats are at present much too high. Flat cliffs on which, according to ancient documents, seals used to be clubbed while enjoying the warm sunbeam, are now quite out of the reach of these amphibious animals. In the years 1731, 1752, and 1755, marks were hewn in some conspicuous rocks, which after the lapse of half a century were found to have risen about two feet higher above the level of the sea. This phenomenon is confined to part of the coast, so that it is clearly the result of a local and slowly progressive upheaving.

Whilst a great part of Scandinavia is thus slowly but steadily rising, the shores of Chili have been found to rise convulsively under the influence of mighty volcanic shocks. Thus after the great earthquake of 1822, the whole coast, for the length of a hundred miles, was found to be three or four feet higher than before, and a further elevation was observed after the earthquake of Feb. 21st, 1835.

While to the north of Wolstenholme Sound, Kane remarked signs of elevation, a converse depression was observed as he proceeded southwards along the coast of Greenland, Esquimaux huts being seen washed by the sea. The axis of oscillation must be somewhere about 77° N. lat.

At Keeling Island, in the Indian Ocean, Mr. Darwin found evidence of subsidence. On every side of the lagoon, in which the water is as tranquil as in the most sheltered lake, old cocoa-nut-trees were undermined and falling. The foundation-posts of a store-house on the beach, which the inhabitants had said stood seven years before just above high-water mark, were now

daily washed by the tide. Earthquakes had been repeatedly remarked by the inhabitants, so that Darwin no longer doubted concerning the cause which made the trees to fall, and the store-house to be washed by the daily tide.

On the columns of the temple of Serapis, near Puzzuoli, the astonished naturalist sees holes scooped out by Pholades and Lithodomas, twenty-four feet above the present level of the sea. These animals are marine testacea, that have the power of burying themselves in stone, and cannot live beyond the reach of low-water. How then have they been able to scoop out those hieroglyphic marks so far above the level of their usual abodes? for surely marble originally defective was never used for the construction of so proud an edifice. Alternate depressions and elevations of the soil afford us the only key to the enigma. Earthquakes and oscillations, so frequent in that volcanic region, must first have lowered the temple into the sea, where it was acted upon by the sacrilegious molluscs, and then again their upheaving powers must have raised it to its present elevation. Thus, even the solid earth changes its features, and reminds us of the mutability of all created things.

There can be no doubt that, in consequence of the perpetual increase of alluvial deposits, and of the volcanic processes I have mentioned, the present boundaries of ocean must undergo great alterations in the course of centuries, and the general level of the sea must either rise or fall; but the evidence of history proves to us that, for the last 2000 years at least, there has been no notable change in this respect.

The baths hewn out in the rocks of Alexandria, and the stones of its harbour, have remained unaltered ever since the foundation of the city by the Macedonian conqueror; and the ancient port of Marseilles shows no more signs of a change of level than the old sea-walls of Cadiz. Thus, all the elevations and depressions that have occurred in the bed of ocean, or along its margin, and all the mud and sand that thousands of rivers continually carry along with them into the sea, have left its general level unaltered, at least within the historic ages. However great their effects may appear to the eye that confines itself to local changes, their influence, as far as the evidence of history reaches, has been but slight upon the immensity of the sea.

Geodesical operations have proved that the level of the ocean,

with the exception of certain enclosed seas of limited extent, is everywhere the same. The accurate measurements of Coraboeuf and Delcros show no perceptible difference between the level of the Channel and that of the Mediterranean. In the course of the operations for measuring the meridian in France, M. Delambre calculated the height of Rodez above the level of the Mediterranean at Barcelona, and its height above the ocean which washes the foot of the tower of Dunkirk, and found the difference to be equal to a fraction of a yard.

The measurements which, at Humboldt's suggestion, General Bolivar caused to be executed by Messrs. Lloyd and Filmore, prove that the Pacific is, at the utmost, only a few feet higher than the Caribbean Sea, and even that the relative height of the two seas changes with the tides.

The long and narrow inlet of the Red Sea, which, according to former measurements, was said to be twenty-four or thirty feet higher than the Mediterranean seems, from more recent and accurate investigations, to be of the same level, and thus to form no exception to the general rule.

The salts contained in sea water, and to which it owes its peculiar bitter and unpleasant taste, form about three and a half per cent. of its weight, and consist principally of common table salt (chloride of sodium), and the sulphates and carbonates of magnesia and lime. But, besides these chief ingredients, there is scarcely a single elementary body of which traces are not to be found in that universal solvent. Wilson has pointed out fluoric combinations in sea water, and Malaguti and Durocher (Annales de Chimie, 1851) detected lead, copper, and silver in its composition. Tons of this precious metal are dissolved in the vast volume of the ocean, and it contains arsenic sufficient to poison every living thing.

Animal mucus, the product of numberless creatures, is mixed up with the sea water, and it constantly absorbs carbonic acid and atmospheric air, which are as indispensable to the marine animals and plants as to the denizens of the atmospheric ocean.

In inclosed seas, communicating with the ocean only by narrow straits, the quantity of saline particles varies from that

of the high seas. Thus the Mediterranean, when evaporation is favoured by heat, contains about one half per cent. more salt than the ocean; while the Baltic, which, on account of its northern position, is not liable to so great a loss, and receives vast volumes of fresh water from a number of considerable rivers, is scarcely half so salt as the neighbouring North Sea.

In the open ocean, the perpetual circulation of the waters produces an admirable equality of composition: yet Dr. Lenz, who accompanied Kotzebue in his second voyage round the world, and devoted great attention to the subject, found that the Atlantic, particularly in its western part, contains a somewhat larger proportion of salts than the Pacific; and that the Indian Ocean, which connects those vast volumes of water, is more salt towards the former than towards the latter.

As water is a bad conductor of caloric, the temperature of the seas is in general more constant than that of the air.

The equinoctial ocean seldom attains the maximum warmth of 83°, and has never been known to rise above 87°; while the surface of the land between the tropics is frequently heated to 129°. In the neighbourhood of the line, the temperature of the surface-water oscillates all the year round only between 82° and 85°, and scarce any difference is perceptible at different times of the day.

The wonderful sameness and equability of the temperature of the tropical ocean over spaces covering thousands of square miles, particularly between 10° N. and 10° S. lat., far from the coasts, and where it is not intersected by pelagic streams, affords, according to Arago, the best means of solving a very important, and as yet unanswered question, concerning the physics of the globe. "Without troubling itself," says that great natural philosopher, "about mere local influences, each century might leave to succeeding generations, by a few easy thermometrical measurements, the means of ascertaining whether the sun, at present almost the only source of warmth upon the surface of the earth, changes his physical constitution, and varies in his splendour like most stars, or whether he has attained a permanent condition. Great and lasting revolutions in his shining orb would reflect themselves more accurately in the

altered mean temperature of those ocean plains than in the changed medium warmth of the dry land."

The warmest part of the ocean does not coincide with the Equator, but seems to form two not quite parallel bands to the north and south.

In the northern Atlantic, the line of greatest temperature (87° F.) which on the African coast is found but a little to the north of the Equator, rises on the north coast of South America as high as 12° N. lat., and in the Gulf of Mexico ranges even beyond the tropic. The influence of the warmth-radiating land on inclosed waters is still more remarkable in the Mediterranean (between 30° and 44° N. lat.) where during the summer months a temperature of 84° and 85° is found, three degrees higher than the medium warmth of the open tropical seas.

While in the torrid zone the temperature of the ocean is generally inferior to that of the atmosphere, the contrary takes place in the Polar seas. Near Spitzbergen, even under 80° N. lat., Gaimard never found the temperature of the water below +33°. Between Norway and Spitzbergen the mean warmth of the water in summer was +39°, while that of the air only attained +37°.

In the enclosed seas of the Arctic Ocean, the enormous accumulation of ice, which the warmth of a short summer is unable totally to dissolve, naturally produces a very low temperature of the waters. Thus, in Baffin's Bay, Sir John Ross found during the summer months only thirty-one days on which the temperature of the water rose above freezing point.

In the depths of the sea, even in the tropical zone, the water is found of a frigid temperature, and this circumstance first led to the knowledge of the submarine polar ocean currents; "for without these, the deep sea temperature in the tropics could never have been lower than the maximum of cold, which the heat-radiating particles attain at the surface." *

It was formerly believed that while the surface temperature—which depended upon direct solar radiation, the direction of currents, the temperature of winds, and other temporary causes—might vary to any amount, at a certain depth the temperature was permanent at 4° C., the temperature of the greatest density of fresh water. Late investigations, however, have led to the

* Humboldt's "Kosmos."

conclusion that instead of there being a permanent deep layer of water at 4° C., the average temperature of the deep sea in temperate and tropical regions is about 0° C., the freezing point of fresh water.

In the atmospheric ocean, aeronauts not seldom meet with warm air currents flowing above others of a colder temperature; while, according to a general law, the warmth of the air constantly diminishes as its elevation above the surface of the sea increases.

Similar exceptions to the general rule are met with in the ocean. In moderate depths sometimes the whole mass of water from the surface to the bottom is abnormally warm, owing to the movement in a certain direction of a great body of warm water, as in the "warm area" to the north-west of the Hebrides, where, at a depth of 500 fathoms, the minimum temperature was found to be 6° C. On the other hand, the whole body of water is sometimes abnormally cold, as in the "cold area," between Scotland and Faeroe, where, at a depth of 500 fathoms, the bottom temperature is found to average $-1°$ C.* The only feasible explanation of these enormous differences of temperature, amounting to nearly 13° F. in two areas freely communicating with one another, and in close proximity, is that in the area to the north-west of the Hebrides a body of water warmed even above the normal temperature of the latitude flows northwards from some southern source, and occupies the whole depth of that comparatively shallow portion of the Atlantic, while an arctic stream of frigid water creeps from the north-eastward into the trough between Faeroe and the Shetland Islands, and fills its deeper part in consequence of its higher specific gravity. There can be no doubt that similar phenomena occur in various parts of the ocean, and that the deep seas are frequently intersected by streams differing in temperature from the surrounding waters.

In some places, owing to the conformation of the neighbouring land or of the sea-bottom, superficial warm and cold currents are circumscribed and localised, thereby occasioning the singular phenomenon of a patch or stripe of warm and a patch of cold sea meeting in an invisible but well-defined line.

* "The Depths of the Sea," by Professor Wyville Thomson, p. 307.

The temperature of the sea apparently never sinks at any depth below −3·5° C. This is about the temperature of the maximum density of sea water, which contracts steadily till just above its freezing point (−3·67° C.), when kept perfectly still.

If we include in the tropical seas all that part of the ocean where the surface temperature never falls below 68° F., and where consequently living coral reefs may occur, we find that it nearly equals in size the temperate and cold ocean-regions added together. This distribution of the waters over the surface of the globe is of the highest importance to mankind; for the immense extent of the tropical ocean, where, of course, the strongest evaporation takes place, furnishes our temperate zone with the necessary quantity of rain, and tends by its cooling influence to diminish the otherwise unbearable heat of the equatorial lands.

The circumstance of ice being lighter than water also contributes to the habitability of our earth. Ice is a bad conductor of heat; consequently it shields the subjacent waters from the influence of frost, and prevents its penetrating to considerable depths. If ice had been heavier than water, the sea-bottom, in higher latitudes, would have been covered with solid crystal at the very beginning of the cold season; and during the whole length of the polar winter, the perpetually consolidating surface-waters would have been constantly precipitated, till finally the whole sea, far within the present temperate zone, would have formed one solid mass of ice. The sun would have been as powerless to melt this prodigious body, as it is to dissolve the glaciers of the Alps, and the cold radiating from its surface would have rendered all the neighbouring lands uninhabitable.

The mixture of the water of rivers with that of the sea presents some hydrostatic phenomena which it is curious enough to observe. Fresh water being lighter, ought to keep at the surface, while the salt water, from its weight, should form the deepest strata. This, in fact, is what Mr. Stephenson observed in 1818 in the harbour of Aberdeen at the mouth of the Dee, and also in the Thames near London and Woolwich. By taking up water from different depths with an instrument invented for the purpose, Mr. Stephenson found that at a certain distance

from the mouth the water is fresh in the whole depth, even during the flow of the tide, but that a little nearer the sea fresh water is found on the surface, while the lower strata consist of sea water. According to his observations it is between London and Woolwich that the saltness of the bottom begins to be perceptible. Thus, below Woolwich the Thames, instead of flowing over a solid bed, in reality flows upon a liquid bottom formed by the water of the sea, with which no doubt it is more or less mixed.

Mr. Stephenson is of opinion that, at the flow of the tide, the fresh water is raised as it were in a single mass by the salt water which flows in, and which ascends the bed of the river, while the fresh water continues to flow towards the sea.

Where the Amazon, the La Plata, the Orinoco, and other giant streams pour out their vast volumes of water into the ocean, the surface of the sea is fresh for many miles from the shore; but this is only superficial, for below, even in the bed of the rivers, the bitterness of salt water is found.

It is a curious fact, that in many parts of the ocean, fresh-water springs burst from the bottom of the sea. Thus, in the Gulf of Spezzia, and in the port of Syracuse, large jets of fresh water mingle with the brine; and Humboldt mentions a still more remarkable submarine fountain on the southern coast of Cuba, in the Gulf of Xagua, a couple of sea miles from the shore, which gushes through the salt water with such vehemence, that boats approaching the spot are obliged to use great caution. Trading vessels are said sometimes to visit this spring, in order to provide themselves in the midst of the ocean with a supply of fresh water.

The sea is not colourless; its crystal mirror not only reflects the bright sky or the passing cloud, but naturally possesses a pure bluish tint, which is only rendered visible to the eye when the light penetrates through a stratum of water of considerable depth. This may be easily ascertained by experiment. Take a glass tube, two inches wide and two yards long, blacken it internally with lamp-black and wax to within half an inch of the end, the latter being closed by a cork. Throw a few pieces of white porcelain into this tube, which, after being filled with pure

sea-water, must be set vertically on a white plate, and then, looking through the open end, you will see the white of the porcelain changed into a light blue tint.

In the Gulf of Naples, we find the inherent colour of the water exhibited to us by Nature on a most magnificent scale. The splendid "Azure cave," at Capri, might almost be said to have been created for the purpose. For many centuries its beauties had been veiled from man, as the narrow entrance is only a few feet above the level of the sea, and it was only discovered in the year 1826, by two Prussian artists accidentally swimming in the neighbourhood. Having passed the portal, the cave widens to grand proportions, 125 feet long, and 145 feet broad, and except a small landing place on a projecting rock at the farther end, its precipitous walls are on all sides bathed by the influx of the waters, which in that sea are most remarkably clear, so that the smallest objects may be distinctly seen on the light bottom at a depth of several hundred feet. All the light that enters the grotto must penetrate the whole depth of the waters, probably several hundred feet, before it can be reflected into the cave from the clear bottom, and it thus acquires so deep a tinge from the vast body of water through which it has passed, that the dark walls of the cavern are illumined by a radiance of the purest azure, and the most differently coloured objects below the surface of the water are made to appear bright blue. Had Byron known of the existence of this magic cave, Childe Harold would surely have sung its beauties in some of his most brilliant stanzas.

All profound and clear seas are more or less of a deep blue colour, while, according to seamen, a green colour indicates soundings. The bright blue of the Mediterranean, so often vaunted by poets, is found all over the deep pure ocean, not only in the tropical and temperate zones, but also in the regions of eternal frost. Scoresby speaks with enthusiasm of the splendid blue of the Greenland seas, and all along the great ice-barrier which under 77° S. lat. obstructed the progress of Sir James Ross towards the pole, that illustrious navigator found the waters of as deep a blue as in the classical Mediterranean. The North Sea is green, partly from its water not being so clear, and partly from the reflection of its sandy bottom mixing with the essentially blue tint of the water. In the Bay of Loanga the sea has

the colour of blood, and Captain Tuckey discovered that this results from the reflection of the red ground-soil.

But the essential colour of the sea undergoes much more frequent changes over large spaces, from enormous masses of minute *algæ*, and countless hosts of small sea-worms, floating or swimming on its surface.

"A few days after leaving Bahia," says Mr. Darwin, "not far from the Abrolhos islets, the whole surface of the water, as it appeared under a weak lens, seemed as if covered by chipped bits of hay with their ends jagged. Each bundle consisted of from twenty to sixty filaments, divided at regular intervals by transverse septa, containing a brownish-green flocculent matter. The ship passed several bands of them, one of which was about ten yards wide, and, judging from the mud-like colour of the water, at least two and a half miles long. Similar masses of floating vegetable matter are a very common appearance near Australia. During two days preceding our arrival at the Keeling Islands, I saw in many parts masses of flocculent matter of a brownish green colour, floating in the ocean. They were from half to three inches square, and consisted of two kinds of microscopical confervæ. Minute cylindrical bodies, conical at each extremity, were involved in large numbers in a mass of fine threads."

"On the coast of Chili," says the same author, "a few leagues north of Conception, the 'Beagle' one day passed through great bands of muddy water; and again, a degree south of Valparaiso, the same appearance was still more extensive. Mr. Sulivan, having drawn up some water in a glass, distinguished by the aid of a lens moving points. The water was slightly stained, as if by red dust, and after leaving it for sometime quiet, a cloud collected at the bottom. With a slightly magnifying lens, small hyaline points could be seen darting about with great rapidity, and frequently exploding. Examined with a much higher power, their shape was found to be oval, and contracted by a ring round the middle, from which line curved little setæ proceeded on all sides, and these were the organs of motion. Their minuteness was such that they were individually quite invisible to the naked eye, each covering a space equal only to the one-thousandth of an inch, and their number was infinite, for the smallest drop of water contained very many. In one day we passed through two spaces of water thus stained, one of which

alone must have extended over several square miles. The colour of the water was like that of a river which has flowed through a red clay district, and a strictly defined line separated the red stream from the blue water."

In the neighbourhood of Callao, the Pacific has an olive-green colour, owing to a greenish matter which is also found at the bottom of the sea, in a depth of 800 feet. In its natural state it has no smell, but when cast on the fire, it emits the odour of burnt animal substances.

Near Cape Palmas, on the coast of Guinea, Captain Tuckey's ship seemed to sail through milk, a phenomenon which was owing to an immense number of little white animals swimming on the surface, and concealing the natural tint of the water.

The peculiar colouring of the Red Sea, from which it has derived its name, is owing to the presence of a microscopic alga, *sui generis*, floating at the surface of the sea and even less remarkable for its beautiful red colour than for its prodigious fecundity.

I could add many more examples, where, either from minute algæ or from small animals, the deep blue sea suddenly appeared in stripes of white, yellow, green, brown, orange or red. For fear, however, of tiring the reader's patience, I shall merely mention the *olive green* water, which covers a considerable part of the Greenland seas. It is found between 74° and 80° N. lat., but its position varies with the currents, often forming isolated stripes, and sometimes spreading over two or three degrees of latitude. Small yellowish Medusæ, of from one-thirtieth to one-twentieth of an inch in diameter are the principal agents that change the pure ultramarine of the Arctic Ocean into a muddy green. According to Scoresby, they are about one-fourth of an inch asunder, and in this proportion a cubic inch of water must contain 64, a cubic foot 110,592, a cubic fathom 23,887,872, and a cubic mile nearly twenty-four thousand billions! From soundings made in the situation where these animals were found, the sea is probably more than a mile deep; but whether these substances occupy the whole depth is uncertain. Provided, however, the depth to which they extend be about 250 fathoms, the immense number of one species mentioned above may occur in a space of two miles square; and what a stupendous idea must we form of the infinitude of

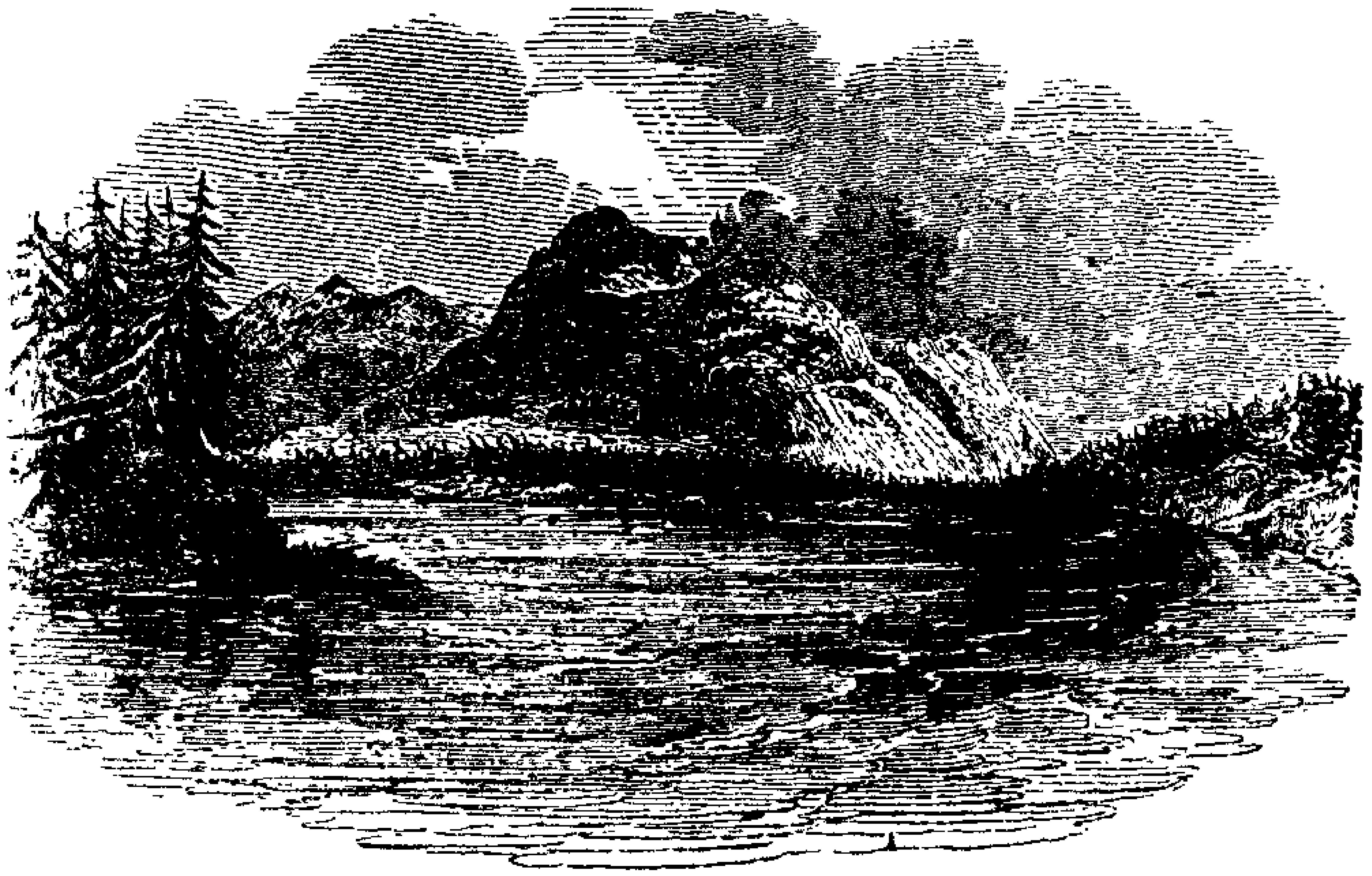
marine life, when we consider that those vast numbers, beyond all human conception, occupy after all only a small part of the green-coloured ocean which extends over twenty or thirty thousand square miles! It is here that the giant whale of the north finds his richest pasture-grounds, which at the same time invite man to follow on his track. A small red crustacean (*Cetochilus australis*) which forms very extensive banks in the Pacific, and in the middle of the Atlantic about 40° S. lat., affords a similar supply of food to the whales frequenting those seas, and exposes them to the same dangers.

When the sea is perfectly clear and transparent, it allows the eye to distinguish objects at a very great depth. Near Mindora, in the Indian Ocean, the spotted corals are plainly visible under twenty-five fathoms of water. The crystalline clearness of the Caribbean sea excited the admiration of Columbus, who in the pursuit of his great discoveries ever retained an open eye for the beauties of nature. "In passing over these splendidly adorned grounds," says Schöpf, "where marine life shows itself in an endless variety of forms, the boat, suspended over the purest crystal, seems to float in the air, so that a person unaccustomed to the scene easily becomes giddy. On the clear sandy bottom appear thousands of sea-stars, sea-urchins, molluscs, and fishes of a brilliancy of colour unknown in our temperate seas. Fiery red, intense blue, lively green, and golden yellow perpetually vary; the spectator floats over groves of sea-plants, gorgonias, corals, alcyoniums, flabellums, and sponges, that afford no less delight to the eye, and are no less gently agitated by the heaving waters, than the most beautiful garden on earth when a gentle breeze passes through the waving boughs."

With equal enthusiasm De Quatrefages expatiates on the beauties of the submarine landscapes on the coast of Sicily. "The surface of the waters, smooth and even like a mirror, enabled the eye to penetrate to an incredible depth, and to recognise the smallest objects. Deceived by this wonderful transparency, it often occurred during my first excursions, that I wished to seize some annelide or medusa, which seemed to swim but a few inches from the surface. Then the boatman smiled, took a net fastened to a long pole, and, to my great astonishment, plunged it deep into the water before it could attain the object which I had supposed to be within my reach. The admirable

clearness of the waters produced another deception of a most agreeable kind. Leaning over the boat, we glided over plains, dales, and hillocks, which, in some places naked and in others carpeted with green or with brownish shrubbery, reminded us of the prospects of the land. Our eye distinguished the smallest inequalities of the piled-up rocks, plunged more than a hundred feet deep into their cavernous hollows, and everywhere the undulations of the sand, the abrupt edges of the stone-blocks, and the tufts of algæ were so sharply defined, that the wonderful illusion made us forget the reality of the scene. Between us and those lovely pictures we saw no more the intervening waters that enveloped them as in an atmosphere and carried our boat upon their bosom. It was as if we were hanging in a vacant space, or looking down like birds hovering in the air upon a charming prospect. Strangely formed animals peopled these submarine regions, and lent them a peculiar character. Fishes, sometimes isolated like the sparrows of our groves, or uniting in flocks like our pigeons or swallows, roamed among the crags, wandered through the thickets of the sea-plants, and shot away like arrows as our boat passed over them. Caryophyllias, Gorgonias, and a thousand other zoophytes unfolded their sensitive petals, and could hardly be distinguished from the real plants with whose fronds their branches intertwined. Enormous dark blue Holothurias crept along upon the sandy bottom, or slowly climbed the rocks, on which crimson sea-stars spread out immoveably their long radiating arms. Molluscs dragged themselves lazily along, while crabs, resembling huge spiders, ran against them in their oblique and rapid progress, or attacked them with their formidable claws. Other crustaceans, analogous to our lobsters or shrimps, gambolled among the fuci, sought for a moment the surface waters to enjoy the light of heaven, and then by one mighty stroke of their muscular tail, instantly disappeared again in the obscure recesses of the deep. Among these animals whose shapes reminded us of familiar forms appeared other species, belonging to types unknown in our colder latitudes: *Salpæ*, strange molluscs of glassy transparency, that, linked together, form swimming chains; great *Beroës*, similar to living enamel; *Diphyæ* hardly to be distinguished from the pure element in which they move, and finally, *Stephanomiæ*, animated garlands woven of crystal and

flowers, and which, still more delicate than the latter, disappear as they wither, and do not even leave a cloud behind them in the vase, which a few moments before their glassy bodies had nearly entirely filled."



Hill at the Rapid on Bear Lake River. (North-West Territory, North America.)

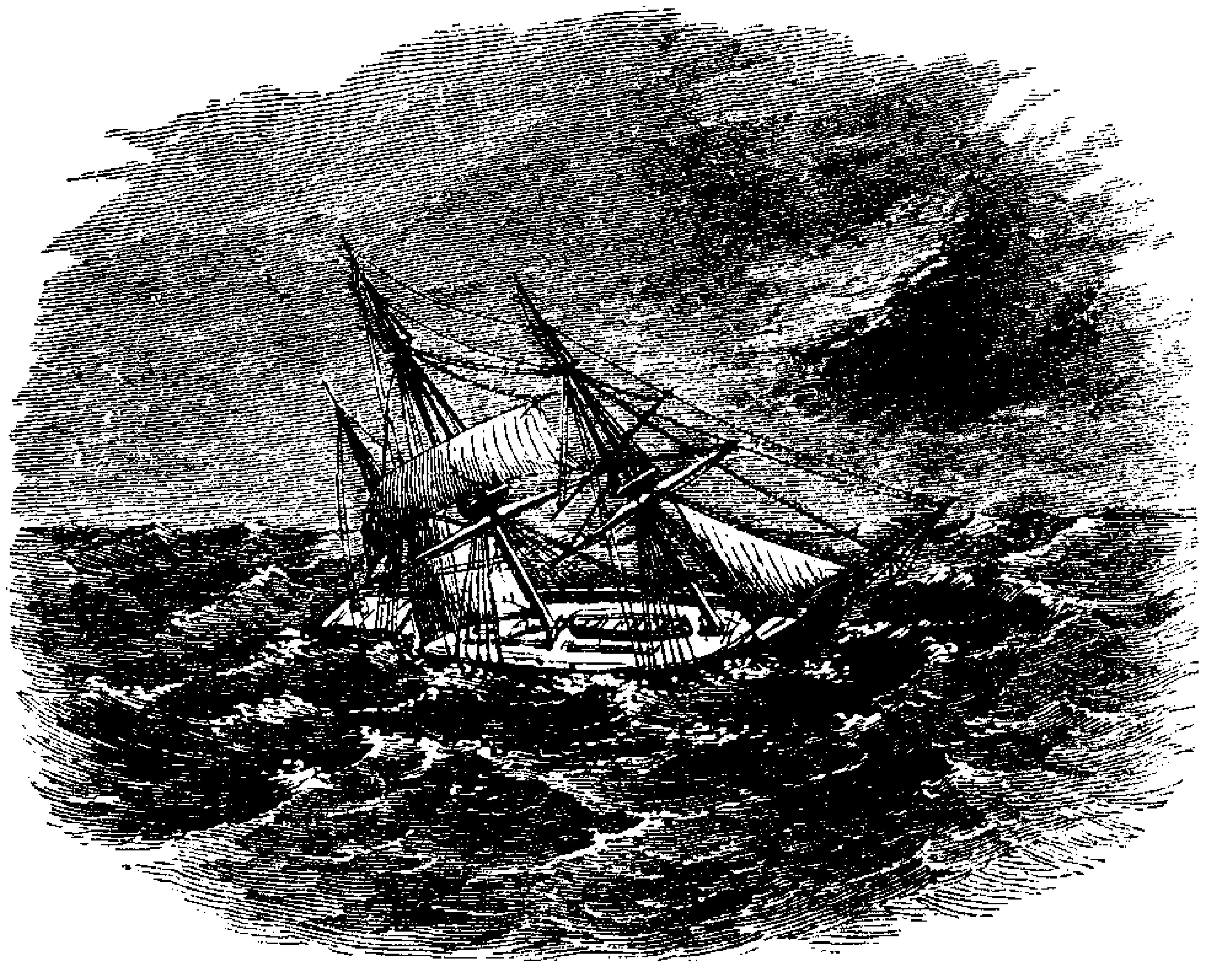
CHAP. II.

THE WAVES OF THE OCEAN.

Waves and the Mode of their Formation.—Height and Velocity of Storm-Waves on the High Seas, according to the Calculations of Scoresby, Arago, Sir James Ross, and Wilkes—Their Height and Power on Coasts—Their Destructive Effects along the British Shore.—Dunwich.—Reculver.—Shakspeare's Cliff.

After having admired the sea in the grandeur of its expanse, and the profundity of its depths, I shall, in this and the two following chapters, examine in what manner the perpetual circulation of its waters is maintained.

"The movements of the sea," says Humboldt, "are of a threefold description: partly irregular and transitory, depending



H.M.S. "Resolute" lying-to in the North Atlantic.

upon the winds, and occasioning waves; partly regular and periodical, resulting from the attraction of the sun and the moon

(ebb and flood); and partly permanent, though of unequal strength and rapidity at different periods (oceanic currents)."

Who has ever sojourned on the coast, or crossed the seas, and has not been delighted by the aspect of the waves, so graceful when a light breeze curls the surface of the waters, so sublime when a raging storm disturbs the depths of the ocean?

But it is easier to admire the beauty of a wave than clearly to explain its nature, so as to convey an accurate or sufficiently general conception of its formation to the reader's mind. Those who are placed for the first time on a stormy sea, discover with wonder that the large waves which they see rushing along with a velocity of many miles an hour do not carry the floating body along with them, but seem to pass under the bottom of the ship with scarcely a perceptible effect in carrying the vessel out of its course.

In like manner, the observer near the shore perceives that floating pieces of wood are not carried towards the shore with the rapidity of the waves, but are left nearly in the same place after the wave has passed them as before. Nay, if the tide be ebbing, the waves may even be observed rushing with great velocity towards the shore, while the body of water is actually receding, and any object floating in it is carried in the opposite direction to the waves out to sea.

What, then, is wave-motion as distinct from water-motion? The force of the wind, pushing a given mass of water out of its place into another, dislodges the original occupant, which is again pushed forward on the occupant of the next place, and so on. As the water-particles crowd upon one another, in the act of going out of their old places into the new, the crowd forms a temporary heap visible on the surface of the fluid, and as each successive mass is displacing the one before it, the undulation or oscillatory movement spreads farther and farther over the waters. Wave-motion is, in fact, the transference of motion without the transference of matter: of form without the substance, of force without the agent.

The strongest storm cannot suddenly raise high waves, they require time for their development. Fancy the wind blowing over an even sea, and it will set water-particles in motion all over the surface, and thus give the first impulse to the

formation of small waves. Numberless oscillations unite their efforts, and create visible elevations and depressions. Meanwhile, the wind is constantly setting new particles in motion; long before the first oscillations have lost their effect, countless others are perpetually arising, and thus the sum of the propelling powers is constantly increasing, and gradually raising mountain-waves, until their growth is finally limited by the counterbalancing power of the earth's attraction.

As the strength of the waves only gradually rises, it also loses itself only by degrees, and many hours after the tornado has ceased to rage, mighty billows continue to remind the mariner of its extinguished fury. The turmoil of waters awakened by the storm propagates itself hundreds of miles beyond the space where its howling voice was heard, and often, during the most tranquil weather, the agitated sea proclaims the distant war of the elements.

The velocity of waves depends not only on the power of the impulse, but also on the depth of the subjacent waters, as I have already mentioned in the preceding chapter.

For this reason, as increased velocity augments the power of the impulse, the waves in the Atlantic or Pacific, the mean depth of which may be estimated at 12,000 or 18,000 feet, attain a much greater height than in the comparatively shallow North Sea.

The breaking of the waves against the shore arises from their velocity diminishing with their depth. As the small flat wave rolls up the beach, its front part, retarded by the friction of the ground, is soon overtaken by its back, moving in swifter progression, and thus arises its graceful swelling, the toppling of its snow-white crest, and finally its pleasant prattle among the shingles of the strand. This is one of those pictures of nature which Homer describes with such inimitable truth in various places of his immortal poems: he paints with admirable colours the slow rising of the advancing wave, how it bends forward with a graceful curve, and, crowning itself with a diadem of foam, spreads like a white veil over the beach, leaving sea-weeds and shells behind, as it rustles back again into the sea.

The height which waves may attain on the open sea has

been accurately investigated by the late Rev. Dr. Scoresby, during two passages across the Atlantic in 1847 and 1848.

"In the afternoon of March 5th, 1848," says that eminent philosopher, "I stood during a hard gale upon the cuddy-roof or saloon deck of the 'Hibernia:' a height, with the addition of that of the eye, of 23 feet 3 inches above the line of flotation (the ship's course being similar to that of the waves). I am not aware that I ever saw the sea more terribly magnificent; the great majority of the rolling masses of water was more than 24 feet high, (including depression as well as altitude, or reckoning above the mean-level, more than 12 feet). I then went to the larboard paddle-box, about 7 feet higher (30 feet 2 inches up to the eye), and found that one half of the waves rose above the level of the view obtained.

"Frequently I observed long ranges (200 yards), which rose so high above the visible horizon, as to form an angle estimated at two or three degrees when the distance of the wave's summit was about 100 yards from the observer. This would add near 13 feet to the level of the eye, and at least one in half-a-dozen waves attained this altitude. Sometimes peaks or crests of breaking seas would shoot upward, at least 10 or 15 feet higher.

"The average wave was, I believe, fully equal to that of my sight on the paddle-box, or more than 15 feet, and the *mean highest waves,* not including the broken or acuminated crests, rose about 43 feet above the level of the hollow occupied at the moment by the ship. It was a grand storm-scene, and nothing could exceed the pictorial effect of the partial sunbeams breaking through the heavy masses of clouds." From the time taken by a regular wave to pass from stern to stem, Dr. Scoresby calculated its velocity at 2875 feet in each minute, or 32·67 English statute miles in an hour. The mean length of the wave-ridges, was from a quarter to a third of a mile.

To those who might be inclined to doubt the accuracy of these measurements, the remark may suffice that our celebrated countryman had been for years engaged in the northern whale-fishery, where he had ample opportunities for practising his eye in measuring distances. Besides, the conclusions of many other trustworthy observers coincide with the evaluations of Dr. Scoresby.

Thus Captain Wilkes, commander of the U. S. Exploring Expedition, found the height of the waves near Orange Harbour, where they rose higher and more regular than at any other time during the cruise, to be thirty-two feet (depression and altitude), and their apparent progressive motion about twenty-six and a half miles in an hour.

Sir James Ross calculated the height of the waves on a strongly agitated sea at twenty-two feet, and, according to the French naturalists who sailed in the frigate "La Venus," on her voyage round the world, the highest waves they met with never exceeded that measure.

Thus, according to the joint testimony of the most eminent nautical authorities, the waves in the open sea never attain the mountain-height ascribed to them by the exuberant fancy of poets or exaggerating travellers. But when the tempest surge beats against steep crags or rocky coasts it rises to a much more considerable height. The lighthouse of Bell Rock, though 112 feet high, is literally buried in foam and spray to the very top during ground-swells, even when there is no wind. On the 20th November, 1827, the spray rose to the height of 117 feet above the foundation or low-water mark, which, deducting eleven feet for the tide that day, leaves 106 feet for the height of the wave. The strength of that remarkable edifice may be estimated from the fact, that the power of such a giant billow is equivalent to a pressure of three tons per square foot.

In the Shetland Islands, which are continually exposed to the full fury of the Atlantic surge (for no land intervenes between their western shores and America), every year witnesses the removal of huge blocks of stone from their native beds by the terrific action of the waves. "In the winter of 1802," says Dr. Hibbert, in his description of that northern archipelago, "a tabular-shaped mass, eight feet two inches by seven feet, was dislodged from its bed and removed to a distance of from eighty to ninety feet. I measured the recent bed from which a block had been carried away the preceding winter (A.D. 1818), and found it to be seventeen feet and a half by seven feet, and the depth two feet eight inches. The removed mass had been borne to a distance of thirty feet, when it was shivered into thirteen or more lesser fragments, some of which were carried

still farther from 30 to 120 feet. A block nine feet two inches by six feet and a half, and four feet thick, was hurried up the acclivity to a distance of 150 feet."

The great storm of 1824, which carried away part of the breakwater at Plymouth, lifted huge masses of rock, from two to five tons in weight, from the bottom of the weatherside and rolled them fairly to the top of the pile. One block of limestone weighing seven tons was washed round the western extremity of the breakwater, and swept to a distance of 150 feet. In 1807, during the erection of the Bell Rock lighthouse, six large blocks of granite which had been landed on the reef were removed by the force of the sea and thrown over a rising ledge to the distance of twelve or fifteen paces, and an anchor weighing about twenty-two hundredweight was cast upon the surface of the rock.

With such examples before our eyes, we cannot wonder that in the course of centuries all shores exposed to the full shock of the waves, lashing against them with every returning tide, should gradually be wasted and worn away. One kind of stone stands the brunt of the elements longer than another, but ultimately even the hardest rock must yield to the rage of the billows, which when provoked by wintry gales, batter against them with all the force of artillery.

Thus, all along our coasts we find innumerable instances of their destructive power. Tynemouth Castle now overhangs the sea, although formerly separated from it by a strip of land, and in the old maps of Yorkshire we find spots, now sandbanks in the sea, marked as the ancient sites of the towns and villages of Auburn, Hartburn, and Hyde. The cliffs of Norfolk and Suffolk are subject to incessant and rapid decay. At Sherringham, Sir Charles Lyell ascertained, in 1829, some facts which throw light on the rate at which the sea gains upon the land. There was then a depth of twenty feet (sufficient to float a frigate) at one point in the harbour of that port, where only forty-eight years ago there stood a cliff fifty feet high with houses upon it! "If once in half a century," remarks the great geologist, "an equal amount of change were produced suddenly by the momentary shock of an earthquake, history would be filled with records of such wonderful revolutions of the earth's surface; but if the conversion of high land into deep sea be

gradual, it excites only local attention." On the same coast, the ancient villages of Shipden, Wimpwell, and Eccles have disappeared, several manors and large portions of neighbouring parishes having gradually been swallowed up; nor has there been any intermission, from time immemorial, in the ravages of the sea along a line of coast twenty miles in length in which these places stood. Dunwich, once the most considerable seaport on the coast of Suffolk, is now but a small village with about one hundred inhabitants. From the time of Edward the Confessor, the ocean has devoured, piece after piece, a monastery, seven churches, the high road, the town-hall, the gaol, and many other buildings. In the sixteenth century not one-fourth of the ancient town was left standing, yet, the inhabitants retreating inland, the name has been preserved,—

"Stat magni nominis umbra,"—

as has been the case with many other ports, when their ancient site has been blotted out.

The Isle of Sheppey is subject to such rapid decay, that the church at Minster, now near the coast, is said to have been in the middle of the island fifty years ago, and it has been conjectured that at the present rate of destruction, the whole isle will be annihilated before the end of the century.

Another remarkable instance of the destructive action of the tidal surge is that of Reculver, on the Kentish coast, an important military station in the time of the Romans, now nothing but a ruin and a name. So late as the reign of Henry VIII., Reculver was still a mile distant from the sea; but, in 1780, the encroaching waves had already reached the site of the ancient camp, the walls of which, cemented as they were into one solid mass by the unrivalled masonry of the Romans, continued for several years after they were undermined to overhang the sea. In 1804, part of the churchyard with the adjoining houses was washed away, and then the ancient church with its two lofty spires, a well-known landmark, was dismantled and abandoned as a place of worship.

Shakspeare's Cliff at Dover has also suffered greatly from the waves, and continually diminishes in height, the slope of the hill being towards the land. About the year 1810, there was

an immense landslip from this cliff, by which Dover was shaken as if by an earthquake, and a still greater one in 1772.

Thus the fame of the poet is likely to outlive for many centuries the proud rock, the memory of which will always be entwined with his immortal verse:—

> "How fearful,
> And dizzy 'tis to cast one's eyes so low!
> The crows, and choughs, that wing the midway air,
> Show scarce so gross as beetles: half way down
> Hangs one that gathers samphire; dreadful trade!
> Methinks, he seems no bigger than his head.
> The fishermen, that walk upon the beach,
> Appear like mice; and yon tall anchoring bark,
> Diminish'd to her cock; her cock, a buoy
> Almost too small for sight. The murmuring surge,
> That on th' unnumber'd idle pebbles chafes,
> Cannot be heard so high."

The peninsulas of Purbeck and Portland, the cliffs of Devonshire and Cornwall, the coasts of Pembroke and Cardigan, the stormy Hebrides, Shetland and Orcadia, all tell similar tales of destruction, a mere summary of which would swell into a volume.

During the most violent gales the bottom of the sea is said by different authors to be disturbed to a depth of 300, 350, or even 500 feet, and Sir Henry de la Bêche remarks that when the depth is fifteen fathoms, the water is very evidently discoloured by the action of the waves on the mud and sand of the bottom. But in the deep caves of ocean all is tranquil, all is still, and the most dreadful hurricanes that rage over the surface leave those mysterious recesses undisturbed.

CHAP. III.

THE TIDES.

Description of the Phenomenon.—Devastations of Storm-Floods on Flat Coasts.—What did the Ancients know of the Tides? —Their Fundamental Causes revealed by Kepler and Newton.—Development of their Theory by La Place, Euler, and Whewell.—Vortices caused by the Tides.—The Maelstrom.—Charybdis.—The *Barre* at the mouth of the Seine.—The Euripus.

Living on the sea-coast would undoubtedly be deprived of one of its greatest attractions, without the phenomenon of the tides, which, although of daily recurrence, never loses the charm of novelty, and gives constant occupation to the fancy by the life, movement, and perpetual change it brings along with it. How wonderful to see the sandy plain on which, but a few hours ago, we enjoyed a delightful walk, transformed into a vast sheet of water through which large vessels plough their way! How agreeable to trace the margin of the rising flood, and listen to its murmurs! Those of the rustling grove or waving cornfield are not more melodious. And then the variety of interesting objects which the reflux of the tide leaves behind it on the beach — the elegantly formed shell, the feathery sertularia, the delicate fucoid, and so many other strange or beautiful marine productions, that may well challenge the attention of the most listless lounger.

But the spectacle of the tides is not merely pleasing to the eye, or attractive to the imagination; it serves also to rouse the spirit of scientific inquiry. It is indeed hardly possible to witness their regular succession without feeling curious to know by what causes they are produced, and when we learn that they are governed by the attraction of distant celestial bodies, and that their mysteries have been so completely solved by man, that he is able to calculate their movements for months and years to come, then indeed the pleasure and admiration we feel at their

aspect must increase, for we cannot walk upon the beach without being constantly reminded that all the shining worlds that stud the heavens are linked together by one Almighty power, and that our spirit, which has been made capable of unveiling and comprehending so many of the secrets of creation, must surely possess something of a divine nature!

On all maritime coasts, except such as belong to mediterranean seas not communicating freely with the ocean, the waters are observed to be constantly changing their level. They regularly rise during about six hours, remain stationary for a few minutes, and then again descend during an equal period of time, when after having fallen to the lowest ebb, they are shortly after seen to rise again, and so on in regular and endless succession. In this manner twelve hours twenty-four minutes elapse on an average from one flood to another, so that the sea twice rises and falls in the course of a day, or rather twice during the time from one passage of the moon through the meridian to the next, a period equivalent on an average to $1\frac{35}{1000}$ day, or nearly twenty-five hours. Thus the tides retard from one day to another; least at new and full moon, when our more active satellite accomplishes her apparent diurnal motion round the earth in twenty-four hours, thirty-seven minutes; and most at half-moon, when, sailing more leisurely through the skies, she takes full twenty-five hours and twenty-seven minutes to perform her daily journey.

As the retarding of the tides regularly corresponds with the retarding of the moon, they always return at the same hour after the lapse of fourteen days, so that at the end of each of her monthly revolutions, the moon always finds them in the same position. The knowledge of this fact is extremely useful to navigators, as it is easy to calculate the time of any tide in a port by knowing when it is high-water on the days of new and full moon.

The height of the tides in the same place is as unequal and changing as the period of their intervals, and is equally dependent on the phases of the moon, increasing with her growth, and diminishing with her decrease. New and full moon always cause a higher rising of the flood (spring-tide), followed by a deeper ebb, while at half-moon the change of level is much less considerable (neap-tide). Thus in Plymouth, for instance, the

neap-tides are only twelve feet high, while the ordinary spring-tides rise to more than twenty feet.

The highest tides take place during the equinoxes; and eclipses of the sun and moon are also invariably accompanied by considerable floods, a circumstance which cannot fail to add to the terror of the ignorant and superstitious when a mysterious obscurity suddenly veils the great luminaries of the sky. It has also been remarked that the tides are stronger or weaker, according as the moon is at a greater or smaller distance from the earth.

Thus as the height of the floods is always regulated by the relative position of the sun and moon, and the movements of these heavenly bodies can be calculated a long time beforehand, our nautical calendars are able to tell us the days when the highest spring-tides may be expected.

This however can only be foretold to a certain extent, as the tidal height not only depends upon the attraction of the heavenly bodies, but also upon the casual influences of the wind, which defies all calculation, and of the pressure of the air. Thus Mr. Walker observed on the coasts of Cornwall and Devonshire that when the barometer falls an inch, the level of the sea rises sixteen inches higher than would otherwise have been the case.

When a strong and continuous wind blows in an opposite direction to the tide-wave, and at the same time the barometer is high, the curious spectators will therefore be deceived in their expectations, however promising the position of the attracting luminaries may be; while an ordinary spring-tide, favoured by a low state of the barometer and chased by a violent storm against the coast, may attain more than double the usual height. When all favourable circumstances combine, an event which fortunately but rarely occurs, those dreadful *storm-tides* take place, as menacing to the flat coasts of the Netherlands as an eruption of Etna to the towns and hamlets scattered along its base, for here also a vast elementary power is let loose which bids defiance to human weakness. It is then that the rebel sea affords a spectacle of appalling magnificence. The whole surface seethes and boils in endless confusion. Gigantic waves rear their monstrous heads like mighty Titans, and hurl their whole colossal power against the dunes and dykes, as if, impelled by a wild lust of conquest, they were burning to devour

the rich alluvial plains which once belonged to their domain. Far inland, the terrified peasant hears the roar of the tumultuous waters, and well may he tremble when the mountain-waves come thundering against the artificial barriers, that separate his fields from the raging floods, for the annals of his country relate many sad examples of their fury, and tell him that numerous villages and extensive meads, once flourishing and fertile, now lie buried fathom-deep under the waters of the sea.

Thus, on the first of November, 1170, the storm-flood, bursting through the dykes, submerged all the land between the Texel, Medenblik, and Stavoren, formed the island of Wieringen, and enlarged the openings by which the Zuiderzee communicated with the ocean. The inundations of 1232 and 1242 caused, each of them, the death of more than 100,000 persons, and that of 1287 swept away more than 80,000 victims in Friesland alone. The irruption of 1395 considerably widened the channels between the Flie and the Texel, and allowed large vessels to sail as far as Amsterdam and Enkhuizen, which had not been the case before. Whilst reading these accounts, we are led to compare the inhabitants of the Dutch lowlands with those of the fertile fields and vineyards that clothe the sides of Vesuvius: both exposed to sudden and irretrievable ruin from the rage of two different elements, and yet both contented and careless of the future; the first behind the dykes that have often given way to the ocean, the latter on the very brink of a menacing volcano.

The tides which sometimes cause such dreadful devastations on the shores of the North Sea are, as is well known, inconsiderable, or even hardly perceptible in the Mediterranean, and thus many years passed ere the Greeks and Romans first witnessed the grand phenomenon. The Phœnicians, the merchant princes of antiquity, who at a very early period of history visited the isolated Britons, —

"Penitus toto divisos orbe Britannos," —

and sailed far away into the Indian Ocean, were of course well acquainted with it; but it first became known to the Greeks through the voyage of Colæus, a mariner of Samos, who, according to Herodotus, was driven by a storm through the Straits of Hercules into the wide Atlantic 600 years before Christ. About

seventy years after this involuntary discovery, the Phoceans of Massilia, or Marseilles, first ventured to follow on the track of Colæus for the purpose of trading with Tartessus, the present Cadiz, and from that time remained in constant commercial intercourse with that ancient Phœnician colony.

With what eager attention may their countrymen have listened to the wondrous tale of the alternate rising and sinking of the ocean! Such must have been the astonishment of our forefathers when the first Arctic voyagers told them of the floating icebergs, and of the perpetually circling sun of the high northern summer.

Thus the tides became known to the Massilians about five centuries before Christ, but in those times of limited international intercourse, knowledge travelled but slowly from place to place; so that it was not before the conquests of Alexander, which first opened the Red Sea and the Persian Gulf to Grecian trade, that the great marine phenomenon began to attract the general attention of philosophers and naturalists.

The flux and reflux of the sea is evidently so closely connected with the movements and changes of the moon, that the intimate relations between both could not possibly escape the penetrating sagacity of the Greeks. Thus we read in Plutarch, that Pytheas of Marseilles, the great traveller who sailed to the north as far as the Ultima Thule, and lived in the times of Alexander the Great, ascribed to the moon an influence over the tides. Aristotle expressed the same opinion, and Cæsar says positively (Commentaries, *De Bel. Gal.* book iv. 29,) that the full-moon causes the tides of the ocean to swell to their utmost height. Strabo distinguishes a three-fold periodicity of the tides according to the daily, monthly, and annual position of the moon, and Pliny expresses himself still more to the point, by saying that the waters move as if obeying the thirsty orb which causes them to follow its course.

This vague notion of obedience or servitude was first raised by Kepler to the clear and well defined idea of an attractive power. According to this great and self-taught genius, all bodies strive to unite in proportion to their masses. "The earth and moon would mutually approach and meet together at a point, so much nearer to the earth as her mass is superior to that of the moon, if their motion did not prevent it. The moon

attracts the ocean, and thus tides arise in the larger seas. If the earth ceased to attract the waters, they would rise and flow up to the moon."

The general notion of a mutual attraction, however, did no more than point out the way for the solution of the problem, and it was reserved to our great Newton to accomplish the prophecy of his great predecessor, "that the discovery of the true laws of gravitation would be accomplished in a future generation, when it should please the Almighty Creator of nature to reveal her mysteries to man."

Newton was the first who proved that the tide-generating power of a celestial body arises from the difference of the attraction it exerts on the centre and the surface of the earth. Thus it was at once made clear how the water not only rises on the surface facing the moon, but also on the opposite side of the earth, as in the latter case the moon acts more strongly on the mass of the earth than on the waters which cover the hemisphere most distant from her. The evident consequence is that the earth *sinks* (so to say), on the surface turned from the moon, whereby a deepening of the waters, or, in other words, a rising of the tide, is occasioned.

It now also became clear how the moon, whose attractive power upon the earth is 160 times smaller than that of the sun, is yet able to occasion a stronger tide, since, from her proximity to the earth, she attracts the surface more forcibly than the centre with the thirtieth part of her power, while the distant sun occasions a difference of attraction on these two points equal only to one twelve-thousandth part of her attractive force.

Now also a full explanation was first given why the highest tides take place at new and full moon: that is, when the moon stands between the sun and the earth; or the latter between the sun and the moon; as then the two celestial bodies unite their powers; while at half-moon the solar tide corresponding with the lunar ebb, or the lunar tide with the solar ebb, counteract each other.

But even Newton explained the true theory of the tides only in its more prominent and general features, and the labours of other mathematicians, such as MacLaurin, Bernoulli, Euler, La Place, and Whewell, were required for its further development,

so as fully to explain all the particulars of the sublime phenomenon.

The reproach has often been made to science, that she banishes poetry from nature, and disenchants the forest and the field; but this surely is not the case in the present instance, for what poetical fiction can fill the soul with a grander image than that of the eternal restlessly-progressing tide-wave, which, following the triumphant march of the sun and moon, began as soon as the primeval ocean was formed, and shall last uninterruptedly as long as our solar system exists!

Were the whole earth covered with one sea of equal depth, the tides would regularly move onwards from east to west, and everywhere attain the same height under the same latitude. But the direction and the force of the tide-wave are modified by many obstacles on its way, such as coast-lines and groups of islands, and it has to traverse seas of very unequal depth and form. Flat coasts impede its current by friction, while it rolls faster along deep mural coasts. From all these causes the strength of the tides is very unequal in different places.

They are generally low on the wide and open ocean. Thus the highest tides at Otaheiti do not exceed eleven inches, three feet at St. Helena, one foot and a half at Porto Rico.

But when considerable obstructions oppose the progress of the tide-waves, such as vast promontories, long and narrow channels, or bays of diminishing width, and mouths of rivers directly facing its swell, it rises to a very great height. Thus, at the bottom of Fundy Bay, which stretches its long arm between Nova Scotia and New Brunswick, the spring-tides rise to sixty, seventy, or even one hundred feet, while at its entrance they do not exceed nine feet, and their swell is so rapid as frequently to sweep away cattle feeding on the shore.

The Bristol Channel and the bay of St. Malo in Brittany, are also renowned for their high tides. Near Chepstow, the flux is said sometimes to reach the surprising height of seventy feet, and at St. Malo the floods frequently rise to forty and fifty feet. When the water is low, this small seaport town appears surrounded on all sides by fantastically shaped cliffs covered with seaweeds and barnacles. Pools of salt water interspersed here and there among the hollowed stones, or on the even ground between them, and harbouring many curious varieties of marine animals,

are the only visible signs of the vicinity of the ocean, whose hoarse murmurs are heard resounding from afar. But an astonishing change takes place a few hours after, when the town, surrounded by the sea, would be a complete island, but for a long, narrow causeway called "*the Sillon*," which connects it with the mainland. On the side fronting the open sea, the tide breaks with tremendous rage against the strong buttresses that have been raised to oppose its fury, rises foamingly to a height of thirty or forty feet, and threatens the tardy wanderer as he loiters on the narrow causeway. The cliffs that erewhile were seen to surround the town are now hidden under the waters, some few excepted, that raise their rugged heads like minute islands above the circumambient floods. The opposite side of the causeway is also washed by the sea; but here its motions are less tumultuous, for after having broken against numberless rocks and made a vast circuit, it scarce retains a vestige of its primitive strength. On this side lies the vast, but deserted harbour of St. Malo, completely dry at ebb-tide; a wide sea during the flood.

Two eminent French authors, Chateaubriand and Lamennais, were born at St. Malo, and there can be no doubt that the imposing spectacle I have briefly described must have greatly contributed to the widening of their intellectual horizon. Daily witnesses from their early childhood of one of the grandest phenomena of nature in all its wild sublimity, the boundless and the infinite soon grew familiar to their mind, enriching it with splendid imagery and bold conceptions.

Although the sun and the moon exert some attraction upon the smaller and inclosed seas, yet the development of a powerful flood-wave necessarily requires that the moon should act upon a sufficiently wide and deep expanse of ocean. Even the Atlantic is not broad enough for this purpose, as its equatorial width measures no more than one eighth of the earth's circumference: and the Pacific itself, notwithstanding its vast area, is so studded with islands and shallows, that it presents a much more obstructed basin for the action of the tide-wave than might be expected, from its apparent dimensions and equatorial position.

Thus it is in the Southern Ocean, where the greatest uninterrupted surface of deep water is exposed to the influence

of the moon, that we must look for the "*chief cradle of the tides.*" From this starting point they flow on all sides to the northward, progressing like any other wave that arises on a small scale in a pond from a gust of wind, the throwing of a stone, or any other cause capable of producing an undulating movement on the surface of the waters.

The tide-wave, which ultimately reaches our shores, arrives at the Cape of Good Hope thirteen hours after it has left Van Diemen's Land, and thence rolls onward in fourteen or fifteen hours to the coasts of Spain, France, and Ireland. It penetrates into the North Sea by two different ways. One of its ramifications turns round Scotland and thence flows onwards to the south, taking nineteen or twenty hours for the passage from Galway to the mouth of the Thames. A tide-wave, for instance, which appears at five in the afternoon on the west coast of Ireland, arrives at eight near the Shetland Islands, reaches Aberdeen at midnight, Hull at five in the morning, and Margate at noon.

The other ramification of the same tide-wave, taking the shorter route through the Channel, had meanwhile preceded it by twelve hours, having reached Brest about five o'clock of the afternoon (at the same time that the northern branch appeared at Galway), Cherbourg at seven, Brighton at nine, Calais at eleven, and the mouth of the Thames at midnight.

Thus, in this southern corner of the North Sea, two tide-waves unite that belong to two successive floods; the Scotch branch having started twelve hours sooner from the great Southern Ocean than the Channel branch, which thus results from the next following tide. The meeting of the two branches naturally gives rise to a more considerable rising of the waters, so that this circumstance, by allowing large ships to sail up the Thames, may be considered as one of the fundamental causes of the grandeur of London.

In other parts of the North Sea, where the two tide-waves appear at different times, the contrary takes place, for the ebb of the one coinciding with the rising of the other, they naturally weaken or even neutralise each other. This occasions the low tides on the coast of Jutland, in Denmark, where they are scarcely higher than in the Mediterranean, and explains the otherwise startling fact of there being a space in the North

Sea where no periodical rise and fall of the waters whatsoever takes place.

Thus we see that the relations of the tides in the North Sea, with regard to height and time, are of a somewhat complicated nature, which could only be explained after the numerous observations (amounting to more than 40,000) made by order of the British Government in all parts of the world, under the direction of Professor Whewell, had proved that all the floods of the seas chiefly proceed from the great tide-wave of the Southern Ocean, which, by its numerous ramifications in narrow seas or through groups of islands and by the unequal rapidity of its progress, according to the depth or shallowness of the waters it traverses, occasions all the seeming anomalies which were quite inexplicable by the simple Newtonian theory.

As every twelve hours a new tidal-wave originates in the Southern Ocean which regularly follows in the same track as its predecessor, the tides everywhere succeed each other in regular and equal periods, and can thus everywhere be calculated beforehand.

In narrow straits or in the intricate channels which wind through clusters of islands, different tidal-waves meeting from opposite directions give rise to more or less dangerous whirlpools. One of the most famous of these vortices, though inconsiderable in itself, is the renowned Charybdis, which gave so much trouble to Ulysses on his passing through the strait which separates Sicily from Italy, but is at present an object of fear scarcely even to the poor fisherman's boat.

A much grander whirlpool, owing its celebrity, not to the fictions of poetry, but to the magnificent scale on which it has been constructed by nature, is the renowned Maelstrom, situated on the Norwegian coast in 68° N. lat., and near the island of Moskoe, from whence it also takes the name of Moskoestrom. It is four geographical miles in diameter, and in tempestuous weather its roar, like that of Niagara, is said to be heard several miles off. John Ramus gives us a terrible description of its fury, and mentions that in the year 1645 it raged with such noise and impetuosity, that on the island of Moskoe, the very stones of the houses fell to the ground. He tells us also that whales frequently come too near the stream, and, notwithstanding their giant strength, are overpowered by its violence,

but, unfortunately adds, that it is impossible to describe their howlings and bellowings in their fruitless struggles to disengage themselves—impossible, no doubt, as whales happen to have no voice at all!

According to more modern travellers, such as the celebrated geologist Leopold von Buch, the Maelstrom is far from being so terrible as depicted by Ramus and other friends of the marvellous; so that, except during storms and spring-tides, large ships may constantly cross it without danger. The Norwegian fishermen are even said frequently to assemble on the field of the Maelstrom on account of the great abundance of fishes congregating in those troubled waters, and fearlessly to pursue their avocations, while the whirlpool moves their boats in a circular direction.

Sir Robert Sibbald describes a very remarkable marine whirlpool among the Orkney islands, which would prove dangerous to strangers, though it is of no consequence to the people who are used to it. It is not fixed to any particular place, but arises in various parts of the limits of the sea among these islands. Wherever it appears, it is very furious, and boats would inevitably be drawn in and perish with it, but the people who navigate them are prepared for it and always carry a bundle of straw or some such matter in the boat with them. This they fling into the vortex which immediately swallows it up, and, seemingly pleased with this propitiatory offering, subsides into smoothness, but soon after re-appears in another place.

A remarkable and sudden rising of the spring-tide takes place at the mouth of several rivers, for instance, the Indus (where the surprising phenomenon nearly caused the destruction of the fleet of Alexander the Great), the Hooghly, the Dordogne, &c. In the Seine it is observed on a scale of great magnitude. While the tide gradually rises near Havre and Harfleur, a giant wave is suddenly seen to surge near Quillebœuf, spanning the whole width of the river (from 30,000 to 36,000 feet). After this mighty billow has struck against the quay of Quillebœuf, it enters a more narrow bed and flows stream-upwards with the rapidity of a race horse, overflowing the banks on both sides, and not seldom causing considerable loss of property by its unexpected appearance. The astonishment it causes is increased when it takes place during serene weather, and without

any signs of wind or storm. A deafening noise announces and accompanies this sudden swelling of the waters, which owes its first origin to the silent action of gravitation, and is the result of the diminishing velocity of the tide-wave over a shallow bottom.

While the tide-wave advances over the deep and open seas with an astonishing rapidity, its progress up the channel of a river is comparatively very slow, partly on account of the reason just mentioned, and partly from its meeting a current flowing in an opposite direction.

Thus, the tide takes no less than twelve hours for its progress from the mouth of the Thames to London, about the time it requires to travel all the way from Van Diemen's Land to the Cape of Good Hope. Consequently, when it is high-water at the mouth of the Thames at three o'clock in the afternoon, for instance, we have not high-water at London Bridge before three o'clock in the following morning, when it is again high water at the Nore. But, in the mean time, there has been low water at the Nore and high water about half-way to London, and while the high water is proceeding to London, it is ebbing at the intermediate places, and is low water there when it is high water at London and at the Nore. If the tide extended as far beyond London as London is from the Nore, we should have three high waters with two low waters interposed. The most remarkable instance of this kind is afforded by the gigantic river of the Amazons, as it appears by the observations of Condamine and others, that, between Para, at the mouth of the colossal stream, and the conflux of the Madera and Marañon, there are no less than seven simultaneous high waters with six low waters between them. Thus, four days after the tide-wave was first raised in the Southern Ocean, its last undulations expire deep in the bosom of the South American wilds.

The Mediterranean is generally supposed to be tideless, but this opinion is erroneous; and in the Adriatic, the flux of the sea is far from being inconsiderable, for, at Venice, the difference between high and low water is sometimes no less than six or even nine feet. Mr. W. Trevelyan, during a summer residence in the old port of Antium, on the Roman coast, found from a series of accurate observations, that the tides regularly succeed each other and attain a height of fourteen inches.

In the eastern Mediterranean new measurements have proved that they are still more considerable, while in the western part of that inclosed sea they are almost imperceptible.

The differences of level caused by the Mediterranean tides, are indeed too inconsiderable to attract the general notice of the inhabitants on the coast, but in the famed Euripus, the narrow channel which separates the island of Eubœa or Negropont from continental Greece, the tide produces the striking phenomenon of very irregular fluctuations of the waters, from one end of the channel to the other.

This phenomenon was of course completely inexplicable to the ancient philosophers, and Aristotle is even said to have drowned himself in the Euripus in a fit of despair, since, with all his prodigious sagacity, he could not possibly solve the mystery. For us, who know that peculiar formations of the sea-bed and coasts are capable of considerably augmenting the force of the floods, and that tidal waves rushing into a narrow channel in opposite directions, and at different times, must necessarily produce irregular fluctuations of the waters, the phenomenon of the Euripus has ceased to be a mystery.

CHAP. IV.

MARINE CAVES.

Effects of the Sea on Rocky Shores.—Fingal's Cave.—Beautiful Lines of Sir Walter Scott.—The Antro di Nettuno.—The Cave of Hunga—Legend of its Discovery.—Marine Fountains.—The Skerries.—The Souffleur in Mauritius.—The Buffadero on the Mexican Coast.

Whoever has only observed the swelling of the tide on the flat coasts of the North Sea, has but a faint idea of the Titanic power which it developes on the rocky shores of the wide ocean. Even in fair weather, the growing flood, oscillating over the boundless expanse of waters, rises in tremendous breakers, so that it is impossible to behold their fury without feeling a conviction that the hardest rock must ultimately be ground to atoms by such irresistible forces.

Day after day, year after year, they renew their fierce attacks, and as in the high Alpine valleys the tumultuous torrents rushing from the glaciers tear deep furrows in the flanks of the mountains, thus it is here the sea which stamps the seal of its might on the vanquished rocks, corrodes them into fantastic shapes, scoops out wide portals in their projecting promontories, and hollows out deep caverns in their bosoms.

Here, also, water appears as the beautifying element, decorating inanimate nature with picturesque forms, and the sea nowhere exhibits more romantic scenes than on the rocky shores against which her waves have been beating for many a millennium. How manifold the shapes into which the rocky shores are worn! how numberless the changes which each varying season, nay, every hour of the day with its constant alternations of ebb and flood, of cloud and sunshine, of storm or calm, produces in their physiognomy! Our coasts abound in beauties such as these; but pre-eminent above all other specimens of Ocean's fantastic architecture is Fingal's Cave, which may well challenge the world to show its equal.

From afar, the small island of Staffa, rising precipitously from the sea, seems destitute of all romantic interest, but on approaching, the traveller is struck with the remarkable basaltic columns of which it is chiefly composed. Most of them rest upon a substratum of solid shapeless rock, and generally form colonnades upwards of fifty feet high, following the contours of the inlets or promontories, and overtopped with smaller hillocks. Along the west coast of the island they are tolerably irregular, but on the south side Staffa appears as an immense Gothic edifice, or rather as a forest of gigantic pillars seemingly arranged with all the regularity of art. The admiration they cause is, however, soon effaced when the vast cave to which the remote islet owes its world-wide celebrity bursts upon the view. Fancy a grotto measuring 250 feet in length by 53 in width at the entrance, and spanned by an arch 117 feet high, which, though gradually sloping towards the interior, still maintains a height of 70 feet at the farthest end of the cavern! The walls consist of rows of huge hexagonal basaltic pillars, which seem regularly to diminish according to the rules of perspective. The roof of the vault is formed of the remnants of similar columns, whose shafts have beyond a doubt been torn away by the sea, which, destroying them one after the other, has gradually excavated this magnificent temple of Nature. All their interstices, like those of the pillars, are cemented with a kind of pale yellow spar, which brings out all the angles and sides of their surfaces, and forms a pleasing contrast with the dark purple colour of the basalt.

The whole floor of the cave is occupied by the sea, the depth of which, even at its farthest end, is above six feet, during ebb-tide; but it is only in perfectly calm weather that a boat is able to venture into the interior, for when the sea is any way turbulent (and this is generally the case among the stormy Hebrides) it is in danger of being hurled against the walls of the grot and dashed to pieces. Under these circumstances, the only access into the cave is by a narrow dyke or ledge running along its eastern wall, about fifteen feet above the water. It is formed of truncated basaltic pillars, over which it is necessary to clamber with great caution and dexterity, as they are always moist and slippery from the dashing spray. Frequently there is only room enough for one foot, and while the left hand grasps that

of the guide, it is necessary to hold fast with the right to a pillar of the wall. As this difficult path is most dangerous in the darkest part of the cave, but few tourists are bold enough to trust themselves to it, for the least false step must infallibly precipitate the adventurous explorer into the seething caldron below. Sometimes a cormorant, fearless of any accident of this kind, has built his nest upon the top of one of the truncated

Fingal's Cave.

pillars, which form the pavement of the pathway, and betrays by a peevish hissing his ill humour at being disturbed in his solitary retreat by the intrusion of man.

The narrow path ultimately widens into a more roomy and slanting space formed of the remains of more than a thousand perpendicular truncated shafts. The back wall consists of a range of unequally sized pillars, arranged somewhat like the tubes of an organ. When the waves rush with tumultuous fury

into the cave and dash their flakes of snow-white foam against its wall, it seems as if the gigantic instrument, touched by an invisible hand, were loudly singing the triumphs of ocean.

Among the beauties of this matchless cave, the clear light must not be forgotten, which, penetrating through the wide portal, produces an agreeable chiaro-oscuro even at its farthest end, so that the eye is able to seize at one glance the full majesty of the splendid hall; nor the pure air which, constantly renewed by the perpetual alternations of the tides, is very different from the chilly dampness which generally reigns in subterranean caverns.

When we consider the resemblance which from its regularity this magnificent work of nature bears to a production of human art, we cannot wonder at its having been ascribed to mortal architecture. But as men of ordinary stature seemed too weak for so colossal an enterprise, it was attributed to a race of giants, who constructed it for their chief and leader, Fingal, so renowned in Gaelic mythology. This belief still lingers among the primitive people of the neighbourhood, though some, being averse to pagan Goliahs, ascribe its workmanship to St. Columban.

The patriotic muse of Walter Scott, who visited the cave in 1810, rises to more than ordinary warmth while describing

"That wondrous dome,
Where, as to shame the temples deck'd
By skill of earthly architect,
Nature herself, it seemed, would raise
A minster to her Maker's praise!
Not for a meaner use ascend
Her columns, or her arches bend;
Nor of a theme less solemn, tells
That mighty surge that ebbs and swells,
And still between each awful pause
From the high vault an answer draws
In varied tones, prolonged and high,
That mocks the organ's melody.
Nor doth its entrance front in vain
To old Iona's holy fane,
That Nature's voice might seem to say,
'Well hast thou done, frail child of clay,
Thy humble powers that stately shrine
Task'd high and hard—but witness mine!'"

Lord of the Isles, canto iv. stanza 10.

The Mediterranean has likewise its marine grottoes of world-wide celebrity, its azure cave of Capri,* which I have previously described, and its Antro di Nettuno, in the island of Sardinia, about twelve miles from the small seaport of Alghero. Unfortunately this superb grotto is very difficult of access, for any wind between the north-west and the south prevents an entry, so that the Algherese assert that 300 out of the 365 days it is impossible to enter it. The first vaulted cavern, forming an antechamber about thirty feet high, has no peculiar beauty, but on crossing a second cavern, in which are about twenty feet of beautifully clear water, and then turning to the left, one finds oneself in an intricate navigation among stalactites with surrounding walls and passages of stalagmites of considerable height. Having passed them and proceeding westerly, one reaches another cavern with a natural column in its centre, the shaft and capital of which, supporting the immense and beautifully fretted roof, reminds one of those in the chapter-house of the cathedral at Wells, and the staircase of the hall at Christ Church, Oxford. It stands, the growing monument of centuries, in all its massive and elegant simplicity with comparatively speaking few other stalagmites to destroy the effects of its noble solitude. In parts of the grotto are corridors and galleries, some 300 and 400 feet long, reminding one of the Moorish architecture of the Alhambra. One of them terminates abruptly in a deep cavern into which it is impossible to descend; but among many other interesting objects is a small chamber the access to which is through a very narrow aperture. After climbing and scrambling through it, one finds oneself in a room the ceiling of which is entirely covered with delicate stalactites, and the sides with fretted open work, so fantastical that one might almost imagine that it was a boudoir of the Oceanides, where they amused themselves with making lime lace. Some of the columns in different parts of the grotto are from seventy to eighty feet in circumference, and the masses of drapery drooping in exquisite elegance are of equally grand proportions.

If a rare chance was required to discover the narrow opening in the cliffs of Capri, behind which one of the loveliest spectacles of nature lies concealed, we well may wonder how the famous cave of Hunga in the Tonga Archipelago ever became

* Chap. i. p. 18.

known, as its entrance even at low water is completely hidden under the surface of the sea. Mariner, to whom we owe our first knowledge of this wonderful play of nature, relates that while he was one day *rat-hunting* * in the island of Hunga with king Finow, who at that time reigned over Tonga, the barbarian monarch took a fancy to drink his *kawa* † in the cave. Mariner, who had absented himself for a few moments from the company, was very much astonished when, returning to the strand, he saw one chieftain after another dive and disappear. He had but just time to ask the last of them what they were about. "Follow me," answered the chieftain, "and I will show thee a place where thou hast never been before, and where Finow and his chieftains are at present assembled." Mariner immediately guessed that this must be the celebrated cave of which he had frequently heard, and, anxious to see it, he immediately followed the diving chieftain, and swimming close after him under the water, safely reached the opening in the rock through which he emerged into the cave. On ascending to the surface, he immediately heard the voices of the company, and still following his guide, climbed upon a projecting ledge on which he sat down. All the light of the cave was reflected from the sea beneath, but yet it was sufficient, as soon as the eye had become accustomed to the twilight, to distinguish the surrounding objects. A clearer light being, however, desirable, Mariner once more dived, swam to the strand, fetched his pistol, poured a good quantity of powder on the pan, wrapped it carefully up in tapa-cloth and leaves, and, providing himself with a torch, returned as quickly as possible to the cave. Here he removed the cloth, a great part of which was still quite dry, and igniting it by the flame of the powder made use of it to light his torch. This was probably the very first time since its creation that the cave had ever been illumined by artificial light. Its chief compartment, which on one side branched out into two smaller cavities, seemed to be about forty feet wide and the mean height above the water amounted to as much. The roof was ornamented in a remarkable manner by stalactites resembling the arches and fantastic ornaments of a Gothic hall. According to a popular

* A favourite pastime of the Polynesian chiefs.

† An intoxicating beverage extracted from the Piper methysticum, a species of pepper plant.

tradition, the chieftain who first discovered this remarkable cave while diving after a turtle, used it subsequently as a place of refuge for his mistress to screen her from the persecutions of the reigning despot. The sea faithfully guarded his secret: after a few weeks of seclusion, he fled with his beloved to the Feejee Islands, and on his returning to his native home after the death of the tyrant, his countrymen heard with astonishment of the wonderful asylum that had been revealed to him by the beneficent sea-gods. Lord Byron adopted this graceful tale as the subject of his poem "The Island, or Christian and his Comrades," and has thus described the cave, no doubt largely adorning it from the stores of his brilliant fancy:

> "Around she pointed to a spacious cave,
> Whose only portal was the keyless wave
> (A hollow archway, by the sun unseen,
> Save through the billows' glassy veil of green,
> On some transparent ocean holiday,
> When all the finny people are at play).
>
> "Wide it was and high;
> And showed a self-born Gothic canopy.
> The arch upreared by Nature's architect,
> The architrave some earthquake might erect;
> The buttress from some mountain's bosom hurl'd,
> When the poles crash'd and water was the world;
> Or harden'd from some earth-absorbing fire,
> While yet the globe reek'd from its funeral pyre.
> The fretted pinnacle, the aisle, the nave,
> Were there, all scoop'd by darkness from her cave.
> There, with a little tinge of fantasy,
> Fantastic faces mopp'd and mow'd on high;
> And then a mitre or a shrine would fix
> The eye upon its seeming crucifix.
> Thus Nature played with the stalactites,
> And built herself a chapel of the seas."

On many rocky shores the ocean has worn out subterraneous channels in the cliffs against which it has been beating for ages, and then frequently emerges in water-spouts or fountains from the opposite end. Thus, in the Skerries, one of the Shetland Islands, a deep chasm or inlet, which is open overhead, is continued under ground and then again opens to the sky in the middle of the island. When the water is high, the waves rise up through this aperture like the blowing of a whale in noise and appearance.

A similar phenomenon is exhibited on the south side of the Mauritius, at a point called "The Souffleur," or "The Blower." "A large mass of rock," says Lieutenant Taylor,* "runs out into the sea from the mainland, to which it is joined by a neck of rock not two feet broad. The constant beating of the tremendous swell, which rolls in, has undermined it in every direction, till it has exactly the appearance of a Gothic building with a number of arches. In the centre of the rock, which is about thirty-five or forty feet above the sea, the water has forced two passages vertically upwards, which are worn as smooth and cylindrical as if cut by a chisel. When a heavy sea rolls in, it of course fills in an instant the hollow caverns underneath, and finding no other egress, and being borne in with tremendous violence, it rushes up these chimneys and flies, roaring furiously, to a height of full sixty feet. The moment the wave recedes, the vacuum beneath causes the wind to rush into the two apertures with a loud humming noise, which is heard at a considerable distance. My companion and I arrived there before high water, and, having climbed across the neck of rock, we seated ourselves close to the chimneys, where I proposed making a sketch, and had just begun when in came a thundering sea, which broke right over the rock itself and drove us back much alarmed.

"Our negro guide now informed us that we must make haste to recross our narrow bridge, as the sea would get up as the tide rose. We lost no time and got back dry enough; and I was obliged to make my sketches from the mainland. In about three-quarters of an hour the sight was truly magnificent. I do not exaggerate in the least when I say that the waves rolled in, long and unbroken, full twenty-five feet high, till, meeting the headland, they broke clear over it, sending the spray flying over to the mainland; while from the centre of this mass of foam, the Souffleur shot up with a noise, which we afterwards heard distinctly between two and three miles. Standing on the main cliff, more than a hundred feet above the sea, we were quite wet. All we wanted to complete the picture was a large ship going ashore."

A similar phenomenon, on a still more grand and majestic scale, occurs near Huatulco, a small Mexican village on the

* Journal of the Royal Geographical Society of London, vol. iii. 1833.

THE SOUFFLEUR.

THIS plate shows the sea beating against some hollow rocks on the coast of the Mauritius, and producing the remarkable phenomenon called "The Souffleur," or "The Blower," water-spouts issuing from the wave-worn cavities of the cliff to a considerable height, and with a noise distinctly audible at a distance of three miles.

THE SOUFFLEUR ROCK MAURITIUS.

coast of the Pacific. On sailing into the bay one hears a distant noise, which might be taken for the spouting of a gigantic whale, or the dying groans of a bull struck by the sharp steel of the matador, or the rolling of thunder. Anxious to know the cause, "It is the Buffadero," answer the boatmen, pointing to a fantastically-shaped rock towards which they are rowing. On approaching, a truly magnificent spectacle reveals itself; for a colossal fountain springs from an aperture in the rock to a hight of 150 feet, and after having dissolved in myriads of gems, returns to the foaming element which gave it birth. This beautiful sight renews itself as often as the breakers rush against the rock, and must be of unequalled splendour when a tornado sweeps across the ocean and rolls its giant billows into the hollowed bosom of the cliff.

CHAP. V.

OCEAN CURRENTS.

Causes of the Oceanic Currents.—The Equatorial Stream.—The Gulf Stream.—Its Influence on the Climate of the West European Coasts.—The Cold Peruvian Stream.—The Japanese Stream.

PERPETUAL motion and change is the grand law, to which the whole of the created universe is subject, and immutable stability is nowhere to be found, but in the Eternal mind that rules and governs all things. The stars, which were supposed to be *fixed* to the canopy of heaven, are restless wanderers through the illimitable regions of space. The hardest rocks melt away under the corroding influence of time, for the elements never cease gnawing at their surface, and dislocating the atoms of which they are composed. Our body appears to us unchanged since yesterday, and yet how many of the particles which formed its substance, have within these few short hours, been cast off and replaced by others. We fancy ourselves at rest, and yet a torrent of blood, propelled by an indefatigable heart, is constantly flowing through all our arteries and veins.

A similar external appearance of tranquillity might deceive the superficial observer, when sailing over the vast expanse of ocean, at a time when the winds are asleep, and its surface is unruffled by a wave. But how great would be his error! For every atom of the boundless sea is constantly moving and changing its place; from the depth to the surface, or from the surface to the depth; from the frozen pole to the burning equator, or from the torrid zone to the arctic ocean; now rising in the air in the form of invisible vapours, and then again descending upon our fields in fertilising showers.

The waters are, in fact, the greatest travellers on earth; they know all the secrets of the submarine world; climb the peaks

of inaccessible mountains, shame the flight of the condor as he towers over the summit of the Andes, and penetrate deeper into the bowels of the earth than the miner has ever sunk his shaft.

Leaving their wanderings through the regions of air to the next chapter, I shall now describe the principal ocean currents, the simple, but powerful agencies by which they are set in motion, their importance in the economy of nature, and their influence on the climate of different countries.

Even in the torrid zone, the waters of the ocean, like a false friend, are warm merely on the surface, and of an almost icy coldness at a considerable depth. This low temperature cannot be owing to any refrigerating influence at the bottom of the sea, as the internal warmth of the earth increases in proportion to its depth, and the waters of profound lakes, in a southern climate, never show the same degree of cold as those of the vast ocean.

The phenomenon can thus only arise from a constant submarine current of cold water from the poles to the line, and strange as it may seem, its primary cause is to be sought for in the *warming* rays of the *sun*, which, as we all know, distributes heat in a very unequal manner over the surface of the globe.

Heat expands all liquid bodies, and renders them lighter; cold increases their weight by condensation. In consequence of this physical law, the waters of the tropical seas, rendered buoyant by the heat of a vertical sun, must necessarily rise and spread over the surface of the ocean to the north and south, whilst colder and heavier streams from the higher latitudes flow towards the equator along the bottom of the ocean, to replace them as they ascend.

In this manner, the unequal action of the sun calls forth a general and constant movement of the waters from the poles to the equator, and from the equator to the poles; and this perpetual migration is one of the chief causes by which their purity is maintained. These opposite currents would necessarily flow direct to the north or south, were they not deflected from their course by the rotation of the earth, which gradually gives them a westerly or easterly direction.

The unequal influence of the sun in different parts of the globe, and the rotation of the earth, are, however, not the only causes by which the course of ocean-currents is determined.

Violent storms move the waters to a considerable depth, and

retard the flow of rivers, and thus it is to be expected that continuous winds, even of moderate strength, must have a tendency to impel the waters in the same direction.

The steady trade-winds of the tropical zone, and the prevailing westerly winds in higher latitudes, consequently unite their influence with that of the above mentioned causes, in driving the waters of the tropical seas to the west, and those of the temperate zones to the east.

The tides also, which on the high seas generally move from east to west, promote the flow of the ocean in the same direction, and thus contribute to the westerly current of the tropical seas.

Nor must we forget that the obstacles which the ocean-currents meet on their way; such as intervening lines of coast, sand banks, submarine ridges, or mountain chains, have a great influence upon their course, and may even give them a diametrically opposite direction to that which they would otherwise have followed.

Having thus briefly mentioned the origin and causes of the currents, which intersect the seas like huge rivers, I shall now describe such of them as are most important and interesting in a geographical point of view.

In the northern part of the Atlantic, between Europe, North Africa, and the New World, the waters are constantly performing a vast circular or rotatory movement. Under the tropics they proceed like the trade-winds from east to west, assisting the progress of the ships that sail from the Canaries to South America, and rendering navigation in a straight line from Carthagena de Indias to Cumana (stream upwards) next to impossible. This westerly current receives a considerable addition from the *Mozambique* stream, which, flowing from north to south between Madagascar and the coast of Caffraria, proceeds round the southern extremity of Africa, and after rapidly advancing to the north, along the western coast of that continent, as far as the island of St. Thomas, unites its waters with those of the equatorial current, and continues its course right across the Atlantic. In this manner the combined tropical streams reach the eastern extremity of South America (Cape Roque), where they divide into two arms. The one flowing to the south follows the south-eastern coast, and gradually takes a south-

easterly direction, between the tropic of Capricorn and the mouth of the La Plata river, beyond the limits of the trade-winds. Its traces show themselves to the south-east of the Cape of Good Hope, and are finally lost far in the Indian Ocean.

The northern arm of the equatorial stream flows along the north-eastern coast of South America; constantly raising its temperature under the influence of a tropical sun, and progressing with a rapidity of a hundred miles in twenty-four hours (six feet and a half in a second), after having been joined by the waters of the Amazon river. Thus it continues to flow to the east, until the continent of Central America opposes an invincible barrier to its farther progress in this direction, and compels it to follow the windings of the coast of Costa Rica, Mosquitos, Campeche, and Tabasco. It then performs a vast circuit along the shores of the Mexican Gulf, and finally emerges through the Straits of Bahama into the open ocean.

Here it assumes a new name, and forms what navigators call the *Gulf-stream*, a rapid current of tepid water, which, flowing in a diagonal direction, recedes farther and farther from the coast of North America as it advances to the north-east. Under the forty-first degree of latitude it suddenly bends to the east, gradually diminishing in swiftness, and at the same time increasing in width.

Thus it flows across the Atlantic, to the south of the great bank of Newfoundland, where Humboldt found the temperature of its stream several degrees higher than that of the neighbouring and tranquil waters, which form, as it were, the banks of the warm oceanic current. Ere it reaches the western Azores, it divides into two arms, one of which is driven, partly by the natural impulse of its stream, but principally by the prevailing westerly and north-westerly winds, towards the coasts of Europe; while the other, flowing towards the Canary Islands and the western coast of Africa, finally returns into the equatorial current.

In this manner the waters are brought back to the point from which they came, after having performed a vast circuit of 20,000 miles, which it took them nearly three years to accomplish. According to Humboldt's calculations, a boat left to the current, and moving along without any other assistance, would require about thirteen months to float from the Canary Islands to the

Caribbean Sea as far as Caraccas. From Caraccas to the Straits of Florida, it would remain another ten months on the way, for though the direct distance is but short, the current has to perform an enormous circuit of 2500 miles, and flows but slowly in those confined seas. But the accumulated waters having now to force their passage through the narrow channel between Cuba and the Bahama Islands on one side, and Florida on the other, attain so considerable a velocity, that the whole distance from the Havannah to the Bank of Newfoundland, is traversed in forty days. During this passage the Gulf-stream particularly deserves its name, and is easily distinguished from the surrounding waters by its higher temperature and its vivid dark blue colour. Numerous marine animals of the tropical seas,—the flying fish, the neat velella, the purple ianthina, the crosier nautilus, accompany it to latitudes which otherwise would prove fatal to their existence; and, trusting its tepid stream, float or swim along to the north or the north-east.

At the extremity of the Bank of Newfoundland, it becomes broader, wavers more or less in its course, according to the prevailing winds, and at the same time decreases in rapidity, so that the boat would most likely still require from ten to eleven months for this last station of its journey, ere it once more reached the Canary Islands.

The direction of the Gulf-stream explains to us how the productions of tropical America are so frequently found on the shores of the Eastern Atlantic. Humboldt relates that the main-mast of the "Tilbury," a ship of the line, wrecked during the seven years' war on the coast of San Domingo, was carried by the Gulf-stream to the North of Scotland; and cites the still more remarkable fact, that casks of palm oil belonging to the cargo of an English vessel, which foundered on a rock near Cape Lopez, likewise found their way to Scotland, having thus twice traversed the wide Atlantic; first borne from east to west by the equatorial current, and then carried from west to east, between 45° and 55° N. latitude, by means of the Gulf-stream.

Major Rennell ("Investigation of Currents") relates the peregrinations of a bottle, thrown overboard from the "Newcastle," on the 20th of January, 1819, in lat. 38° 52′, and long. 66° 20′, and ultimately found on the 2nd of June, 1820, on the shore of the Island of Arran.

On the 16th of April, 1853, another bottle cast into the waters in the vicinity of the Bank of Newfoundland, on the 15th of March, 1852, was found near Bayonne, not far from the mouth of the Adour.

On the coasts of Orcadia, a sort of fruit, commonly known by the name of *Molucca*, or Orkney beans, are found in large quantities, particularly after storms of westerly wind.

These beans are the produce of West Indian trees (*Anacardium occidentale*), and find their way from the woods of Cuba and Jamaica, to the Ultima Thule of the ancients, by means of the Gulf-stream.

Large quantities of American drift-wood are transported by the same current to the dreary shores of Iceland,—a welcome gift to the inhabitants of a region where the highest tree is but a dwarfish shrub, and cabbages of the size of an apple are raised, as a great rarity, in the governor's garden.

A short time before Humboldt visited the island of Teneriffe, the sea had thrown out the trunk of a North American cedar-tree (*Cedrela odorata*), covered with the mosses and lichens that had grown upon it in the virgin forest.

The Gulf-stream has even contributed to the discovery of America, for it is well known that Columbus was strengthened in his belief in the existence of a western continent, by the stranding on the Azores of bamboos of an enormous size, of artificially carved pieces of wood, of trunks of a species of Mexican pine, and of the dead bodies of two men, whose features, resembling neither those of the inhabitants of Europe nor of Africa, indicated a hitherto unknown race. But not only lifeless and inanimate objects find their way across the wide Atlantic by means of the Gulf-stream and its spreading waters; the living aborigines of the distant regions of America have also sometimes been driven towards the coasts of Europe by the combined action of the currents and the winds. Thus, James Wallace tells us that, in the year 1682, a Greenlander in his boat was seen by many people near the south point of the island of Eda, but escaped pursuit. In 1684 another Greenland fisherman appeared near the island of Wistram. An Esquimaux canoe, which the current and the storm had cast ashore, is still to be seen in the church of Burra. In Cardinal Bembo's "History of Venice," it is related that, in the year 1508, a small

boat with seven strange-featured men, was captured by a French vessel in the North Sea. The description given of them corresponds exactly with the appearance of the Esquimaux; they were of a middle-size, of a dark colour, and had a broad face with spreading features, marked with a violet scar. No one understood their language. They were clothed in seal-skins. They ate raw flesh, and drank blood as we do wine. Six of these men died on the journey; the seventh, a youth, was presented to the King of France, who at that time was residing at Orleans.

The appearance of so-called Indians on the coast of the German Sea, under the Othos and Frederic Barbarossa, or even, as Cornelius Nepos, Pomponius Melas, and Pliny relate, at the time when Quintus Metellus Celer was proconsul in Gaul, may be explained by similar effects of the current and continuous north-easterly winds. A king of the Boians made a present of the stranded dark-coloured men to Metellus Celer. Gomara, in his "General History of the Indies," expresses a belief that these Indians were natives of Labrador, which would be doubly interesting as the first instance recorded in history of the natives of the Old and the New World having been brought into contact with each other. We can easily account for the appearance of Esquimaux on the North European coasts in former times; as during the eleventh and twelve centuries, their race was much more numerous than at present, and extended, as we know, from the researches of Rask and Finn Magnussen, from Labrador to the good Winland, or the shores of the present State of Massachusetts and Connecticut.

If we compare the climates on the opposite coasts of the Northern Atlantic, we find a remarkable difference in favour of the Old World. The frozen regions of Labrador, lie under the same degree of latitude as Plymouth, where the myrtle and laurel remain perpetually verdant in the open air. In New York, which has a more southern situation than Rome, the winter is colder than at Bergen in Norway, which lies 20° farther to the north. While on the northern coasts of the old continent, the waters remain open a great part of the year, even beyond the latitude of 80°, the ice never completely thaws on the opposite shores of Greenland. What a contrast between the Feroe islands, where the harbours are never frozen, where fertile meadows afford pasturage to numerous flocks of sheep,

and even crops of barley reward the labours of the husbandman, and the frightful wildernesses on the shores of Hudson's Straits! —and yet both are situated under the same latitude of 62°.

The milder winter and earlier spring which characterise the north-west coast of Europe, are due, in some measure, to the prevailing westerly winds; but there can be no doubt that they are mainly owing to the influence of the Gulf-stream, which, as we have seen, conveys the heated waters of the Mexican Gulf far to the north-east, and thus imparts warmth to the climate of our native isle. In both seas, on the contrary, which bound the peninsula or island of Greenland, icy currents descend, and continue their course to the south, along the coasts of North America. Near Newfoundland their temperature, in May, is found to be 14° lower than that of the air, and even in spring and the early summer they carry along with them immense ice-blocks, which are frequently drifted as far south as the latitude of New York, and finally disappear in the Gulf-stream.

It is evident that the cold of winter must be increased, and the spring retarded along the North American coasts by these cold streams, just as the coasts of Europe are favoured by streams of a contrary nature; and thus the ocean-currents go a great way to explain the remarkable differences of climate between the opposite shores of the Northern Atlantic.

On this occasion I cannot omit directing the reader's attention to the influence which the far-distant barrier of Central America has upon the climate of Great Britain. Supposing yon narrow belt of land to be suddenly whelmed under the ocean, then instead of circuitously winding round the Gulf of Mexico, the heated waters of the equatorial current would naturally flow into the Pacific, and the Gulf-stream no longer exist. We should not only lose the benefit of its warm current, but cold polar streams, descending farther to the south would take its place, and be ultimately driven by the westerly winds against our coasts. Our climate would then resemble that of Newfoundland, and our ports be blocked up during many months, by enormous masses of ice. Under these altered circumstances, England would no longer be the grand emporium of trade and industry, and would finally dwindle down from her imperial station to an insignificant dependency of some other country more favoured by Nature.

On examining other coast-lands, in different parts of the globe, we shall everywhere find the influence of the reigning currents producing analogous effects to those I have already mentioned.

The Southern Atlantic is not warmed like the European seas by tepid streams, it is exposed on all sides to the free afflux of the cold waters of the Antarctic Ocean, and during the summer months to the influence of drift ice. Thus, the southern extremity of America, Terra del Fuego, the Falkland Islands, South Georgia, Sandwich Land, and other isles of the southern ocean, have a much colder climate than the European coasts and islands situated under the same latitude.

Let us for instance compare the temperature of the Falkland Islands and of Port Famine in the Straits of Magellan, with that of Dublin, which is situated at an equal distance from the line.

		Mean Temperature.		
	Latitude	Winter.	Summer.	Annual.
Dublin	53° 21′ N.	+ 4·0° R.	15·3°	9·6°
Port Famine . . .	53° 38′ S.	+ 0.6	10·0	5·3
Falkland Islands . . .	52° 0′ S.	4·36	11·8	8·24
Feroë Islands . . .	62° 2′ N.	3·9	11·6	7·1

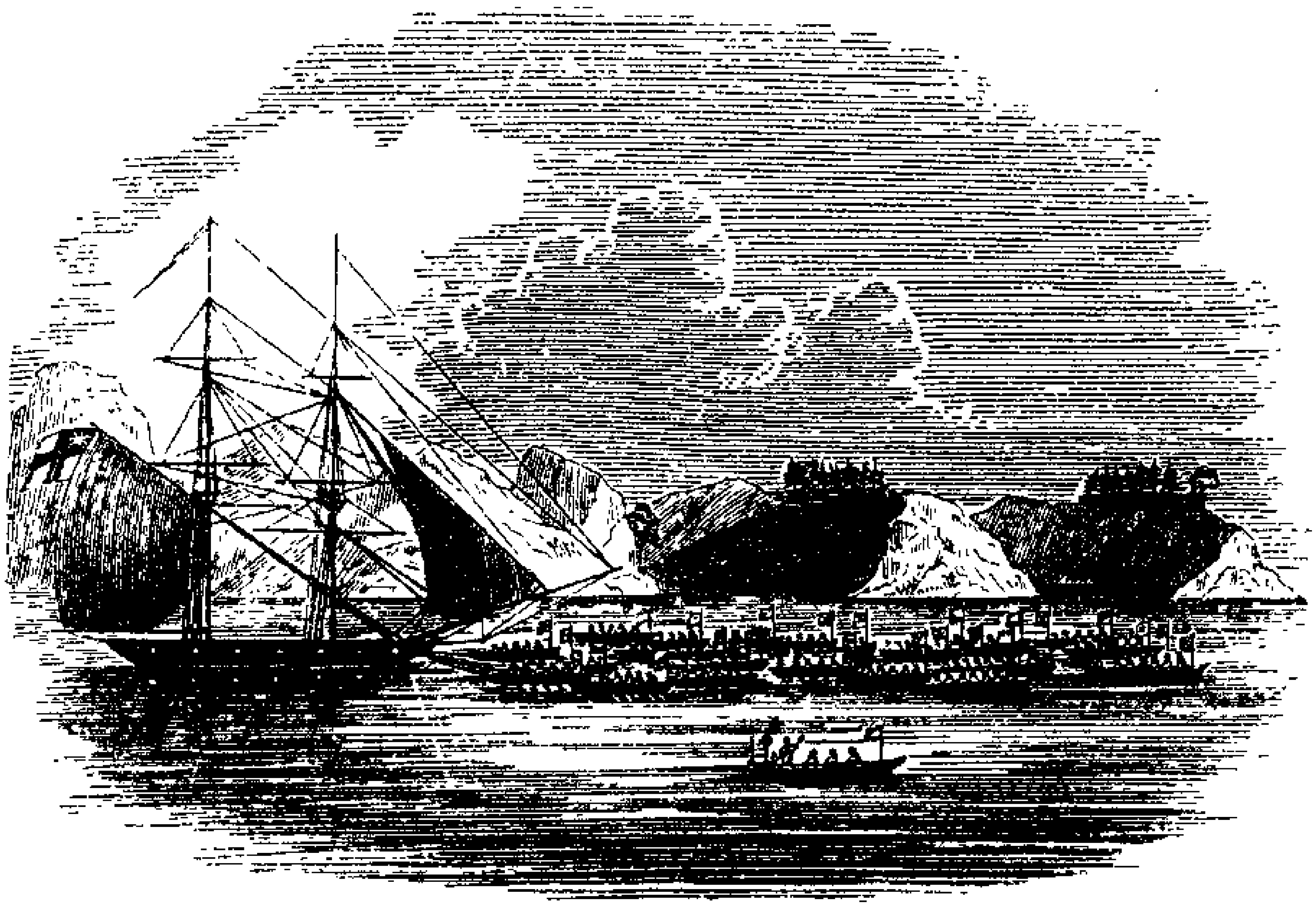
Thus the climate of the Falkland Islands is, as we see, not very different from that of the Feroë Islands, although the latter lie ten degrees farther from the equator.

In the Pacific Ocean, as well as in the Atlantic, we find a westerly current filling the whole breadth of the tropical zone, from the coast of America to that of Australia and the Indian Archipelago. The best known of its affluxes is the cold Peruvian stream, which, emerging from the Polar Sea, flows with great rapidity along the shores of Chili and Peru, and does not take a westerly direction, before reaching the neighbourhood of the line. It has everywhere a remarkably low temperature, comparatively to the latitude, and this sufficiently accounts for the equal and temperate climate on the coasts of Chili and Peru. Thus, the mean temperature of Callao (12° S. lat.) is only 20° R. while in Rio Janeiro (23° S. lat.), though so much farther from the line, the annual warmth rises to 23·2° R.

In the beginning of November, Humboldt found at Callao the temperature of the sea within the current not higher than 15·5°, while outside the stream it rose to 26° or even 28·5° R

Even in the vicinity of the equator, after the current has already assumed a westerly direction, its mean temperature does not exceed 20·5.° But as it advances towards the west, its temperature gradually rises to 27° or 28°.

On the western banks of the Pacific the equatorial stream divides into several branches. Part of its waters flow to the south, a greater quantity penetrates through the channels of the south Asiatic Archipelago into the Indian Ocean, the remainder turns to the north-east, on the confines of the Chinese Sea, leaves the eastern coast of the Japanese Islands, and then



Japan Junks.

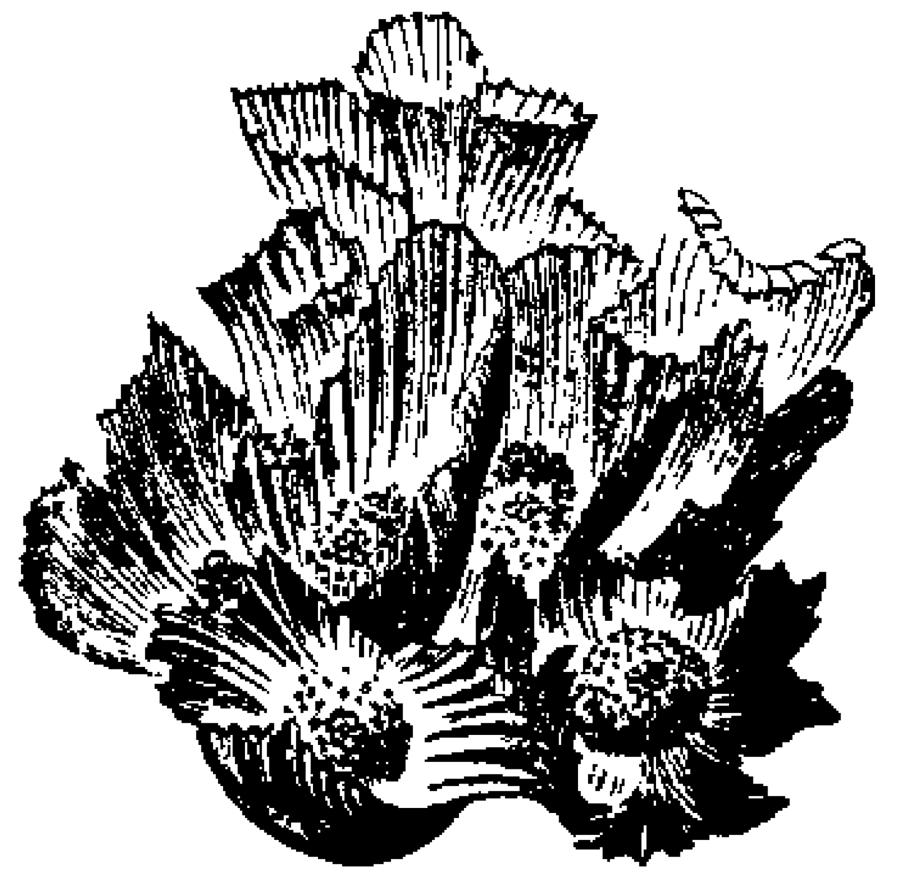
spreads its warm waters under the influence of north-westerly winds over the northern part of the Pacific. Thus the Japanese stream plays here the same part as the Gulf-stream in the Atlantic, and exerts a similar, though less mighty influence over the climate of the west coast of America, as it is neither so large nor so warm, and, having to traverse a wider ocean, in higher latitudes, naturally loses more of its heat during the passage.

It is owing to this stream that Sitcha enjoys a mean annual temperature of + 7° R., while Nain in Labrador, situated under the same latitude, is indebted to the Greenland current for a summer of + 7·8°, a winter of − 18·5°, and a miserable annual temperature of − 3·6°. On the west coast of North America

the analogous trees grow 3° or 4° nearer to the pole, and the aboriginal tribes go naked as far to the north as 52°, a simplicity of toilet that would but ill suit the Esquimaux of Labrador.

Besides their beneficial influence on different climates the ocean-currents tend to equalise, or to maintain the equilibrium of the saline composition of sea-water, and thus secure the existence of numberless marine animals. Their movements also contribute to the formation of sand-banks, where at certain seasons legions of fishes deposit their spawn and invite the persecutions of man.

The rapidity of currents is very different, but always important enough to be taken into account by navigators. The well-informed seaman makes use of them to traverse wide spaces with greater rapidity, and, after an apparently circuitous course, arrives sooner and more safely at his journey's end than the ignorant steersman, who vainly endeavours to strive against their power.



Pavonia Lactuca, with Polypes in Natural Position.

LIGHTHOUSE AND WATERSPOUTS.

LIGHTHOUSE AND WATER-SPOUTS.

A Lighthouse on a rocky shore is represented as just lighted, the twilight having become darkened by a sudden storm, during which the phenomena of "water-spouts" occur, which are represented to the left of the Lighthouse.

CHAP. VI.

THE AËRIAL AND TERRESTRIAL MIGRATIONS OF THE WATERS.

Movements of the Waters through Evaporation.—Origin of Winds.—Trade-Winds.—Calms.—Monsoons.—Typhoons.—Tornadoes.—Water-Spouts.—The Formation of Atmospherical Precipitations.—Dew—Its Origin.—Fog.—Clouds.—Rain.—Snow.—Hail Sources.—The Quantities of Water which the Rivers pour into the Ocean.—Glaciers and their Progress.—Icebergs.—Erratic Blocks.—Influence of Forests on the Formation and Retention of Atmospherical Precipitations.—Consequences of their excessive Destruction.—The Power of Man over Climate.—How has it been used as yet?

NEITHER storms nor ocean-currents, nor ebb and flood, however great their influence, cause such considerable movements of the waters, or force them to wander so restlessly from place to place as the silent and imperceptible action of the warming sunbeam. In every zone evaporation is constantly active in impregnating the atmosphere with moisture, but the chief seat of its power is evidently in the equatorial regions, where the vertical rays of the great parent of light and heat plunge, day after day, into the bosom of ocean, and perpetually saturate the burning air with aqueous vapours.

In this chapter I intend following these invisible agents of fertility and life, as they lightly ascend from the tropical seas, and accompanying them in their various transformations, until they once more return to the bosom of their great parent. A cursory view of the benefits they confer on the vegetable and animal world, as they wander over the surface of the land, will, I hope, agreeably occupy the reader, and serve to increase his admiration for that deep and dark blue ocean without which all organic life would soon be extinct upon earth.

I begin with a few words on the winged carriers of marine exhalations, the *winds*, which, although now and then detrimental or fatal to individuals by their violence, largely compensate for these

local injuries, by the constant and inestimable benefits they confer on the whole body of mankind.

On taking a comprehensive view of their origin, we find that, like the oceanic currents, they are chiefly caused by the unequal influence of solar warmth upon the atmosphere under the line and at the poles. In the torrid zone, the air, rarefied by intense heat, ascends in perpendicular columns high above the surface of the earth, and there flows off towards the poles, in the same manner as in a vase filled with cold water and placed over the flame of a lamp, the warmed liquid rises from the bottom and spreads over the surface.

But cold air-currents must naturally come flowing in an opposite direction from the poles to the equator to fill up the void, as in the example I have cited, colder and consequently heavier water comes streaming down the sides of the vase to replace the liquid which is rising in the centre under the influence of heat.

Thus the unequal distribution of solar warmth over the surface of the earth evidently generates a constant circulation of air from the equator to the poles, and from the icy regions to the tropics, and by this means the purity of the atmosphere is chiefly maintained. The sun is not only the great fountain of warmth, he is also the universal ventilator; he not only calls forth animal life, but at the same time, by a simple and admirable mechanism, provides for its health by constantly renewing the air, which is essential to its existence.

If caloric were the sole agent which influences the direction of the winds, or if the earth were one uniform plain, the opposite air-currents I have mentioned would naturally flow straight to the north and south; but their course is modified or diverted in the same manner as that of the ocean-currents by the rotation of the globe. Thus, the cold air-current (polar-stream) which comes rushing upon us from the Arctic regions, is felt in our latitude as the biting east or north-east wind, so trying to our nerves and organs of respiration, while we enjoy the warm air-current from the tropics as the mild western or south-western breeze.

But besides the rotation of the earth, there are many other local influences by which the winds are deflected from their course, or by whose agency partial air-currents are called forth.

Among these we particularly notice high chains of mountains, the unequal capacity of sea and land in absorbing and retaining heat, which gives rise to sea and land breezes; the increasing or diminishing power of the sun in different seasons by which the equilibrium of the air is modified in many countries, the difference of radiation from a sandy desert or a forest, electrical discharges from clouds, &c. &c.

Although subject to many of these local disturbances, the winds generally blow with an astonishing regularity in the tropical zone; while in our variable climate the polar and equatorial stream are engaged in a perpetual strife, now bringing us warmth and moisture from the south and west, now cold and dryness from the north and east.

Thus, in the Atlantic and Pacific Ocean we find the trade-winds perpetually blowing from the east, the north-east trade-wind between 9° and 27° N. lat., and the south-east trade-wind between 3° N. lat and 25° S. lat. It was by their assistance that Columbus was enabled to discover America, and that the wretched barks of Magellan traversed the wide deserts of the Pacific from end to end.

Between these two regions of the trade-winds lies the dreaded zone or girdle of the equatorial calms (doldrums), where long calms alternate with dreadful storms, and the sultry air weighs heavily upon the spirits.

> "Down dropt the breeze, the sails dropt down,
> 'Twas sad as sad could be;
> And we did speak, only to break
> The silence of the sea.
>
> "Day after day, day after day,
> We stuck, nor breath, nor motion,
> As idle as a painted ship
> Upon a painted ocean."

On their polar limits, the trade-wind zones are again girdled with calm belts, the *horse latitudes*, whose mean breadth is from ten to twelve degrees. The boundaries of these alternating regions of winds and calms are not invariably the same, on the contrary, they are perpetually moving to the north or south, according to the position of the sun.

From 40° N. lat. to the pole, westerly winds begin to be

prevalent, and in the Atlantic Ocean their proportion to the easterly winds is as two to one.

In the Northern Indian Ocean and in the Chinese Sea we also find the trade-wind, which is there called the *north-east monsoon;* here, however, it only blows from October to April, as during the summer terrestrial influences prevail which completely divert it from its course.

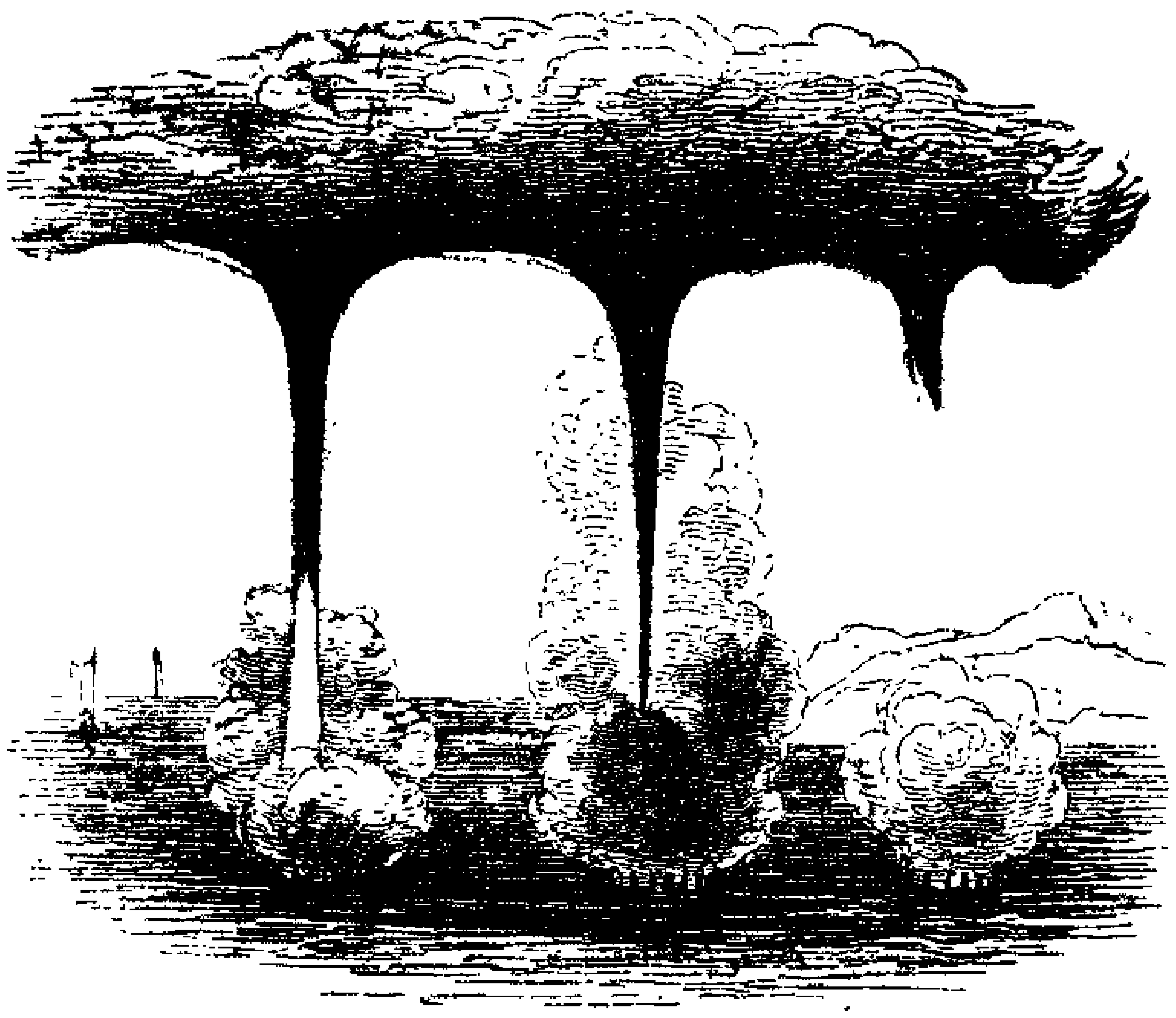
From the wide plains of central Asia, glowing with the rays of a perpetually unclouded sun, the rarefied air rises into the higher regions. Other columns of air rush from the equator to fill up the void, and cause the trade-wind to vary its course, and change into the *south-western monsoons* of the Indian Ocean, which blow from May to September. The regularly alternating monsoons materially contributed to the early development of navigation in the Indian seas, and conducted the Greeks and Romans as far as Ceylon, Malacca, and the Gulf of Siam. Similar monsoons, or deflections from the ordinary course of the trade-winds, occur also in the Mexican Gulf, in the Gulf of Guinea, and in that part of the Pacific which borders on Central America, through the influence of the heated plains of Africa, Utah, Texas, and New Mexico.

The passage from one monsoon to the other is of course only gradual, since the land also is only gradually heated and cooled. Thus at the change of the monsoon, an atmospheric war of several weeks' continuance occurs, during which the trade-wind and the monsoon measure their strength, and calms alternate with dreadful storms (typhoons, cyclones, tornadoes).

According to the researches and observations of Franklin, Cooper, Redfield, Reid, &c. &c., these storms are great rotatory winds, that move along a curved line in increasing circles. In the northern hemisphere, the rotatory movement follows a direction contrary to that of the hands of a clock; while the opposite takes place in the southern hemisphere. The knowledge of the laws which regulate the movements of storms is of great importance to the mariner, since it points out to him the direction he has to give his ship to gain the external limits of the tornado, and thus to remove it from danger.

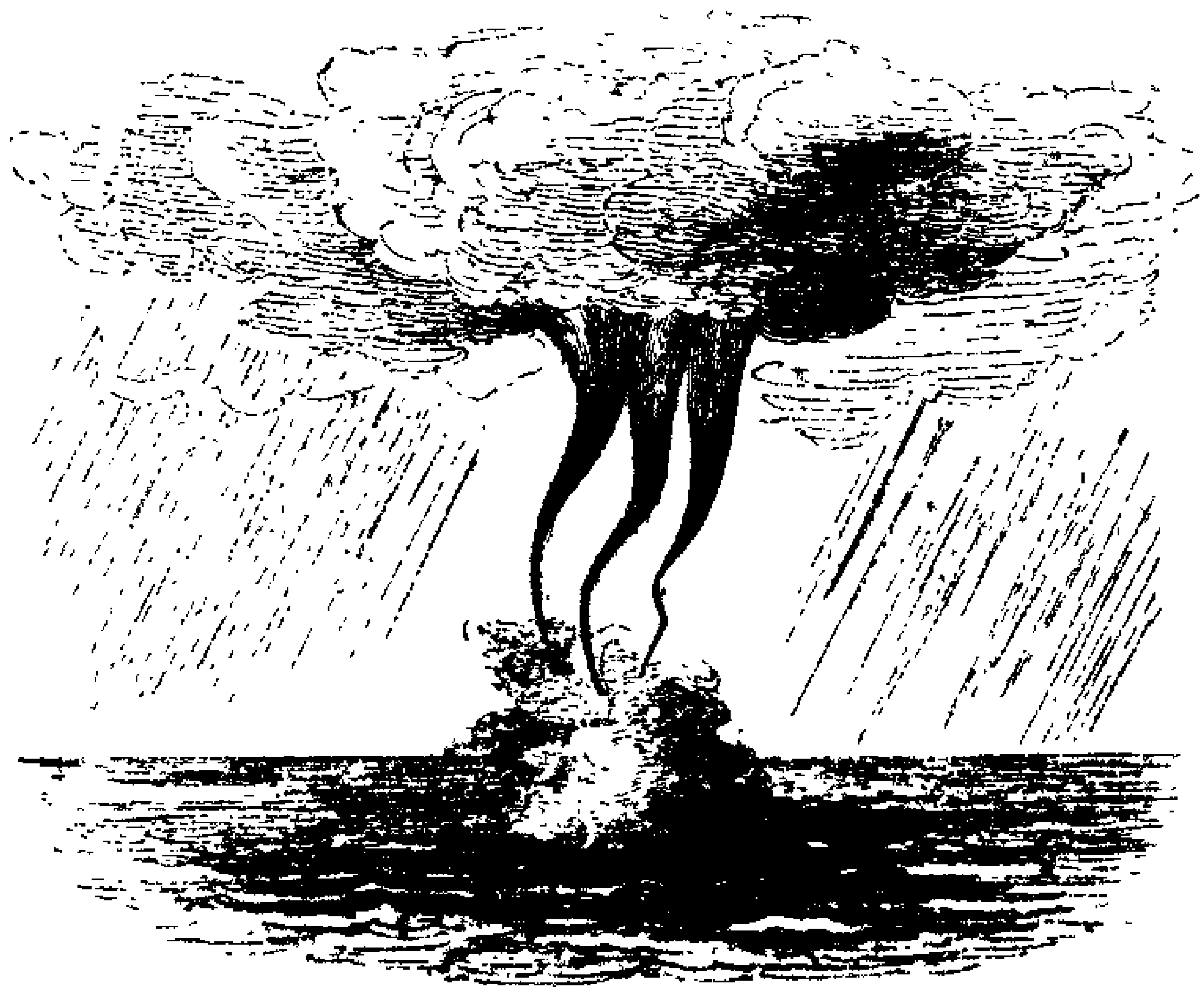
Water-spouts are formed by two winds blowing in opposite directions, and raising or sucking up the water in their vortex They generally form a double cone; the superior part with its

apex downwards, consisting of a dense cloud, while the inferior cone, the apex of which is turned upwards, consists of water,



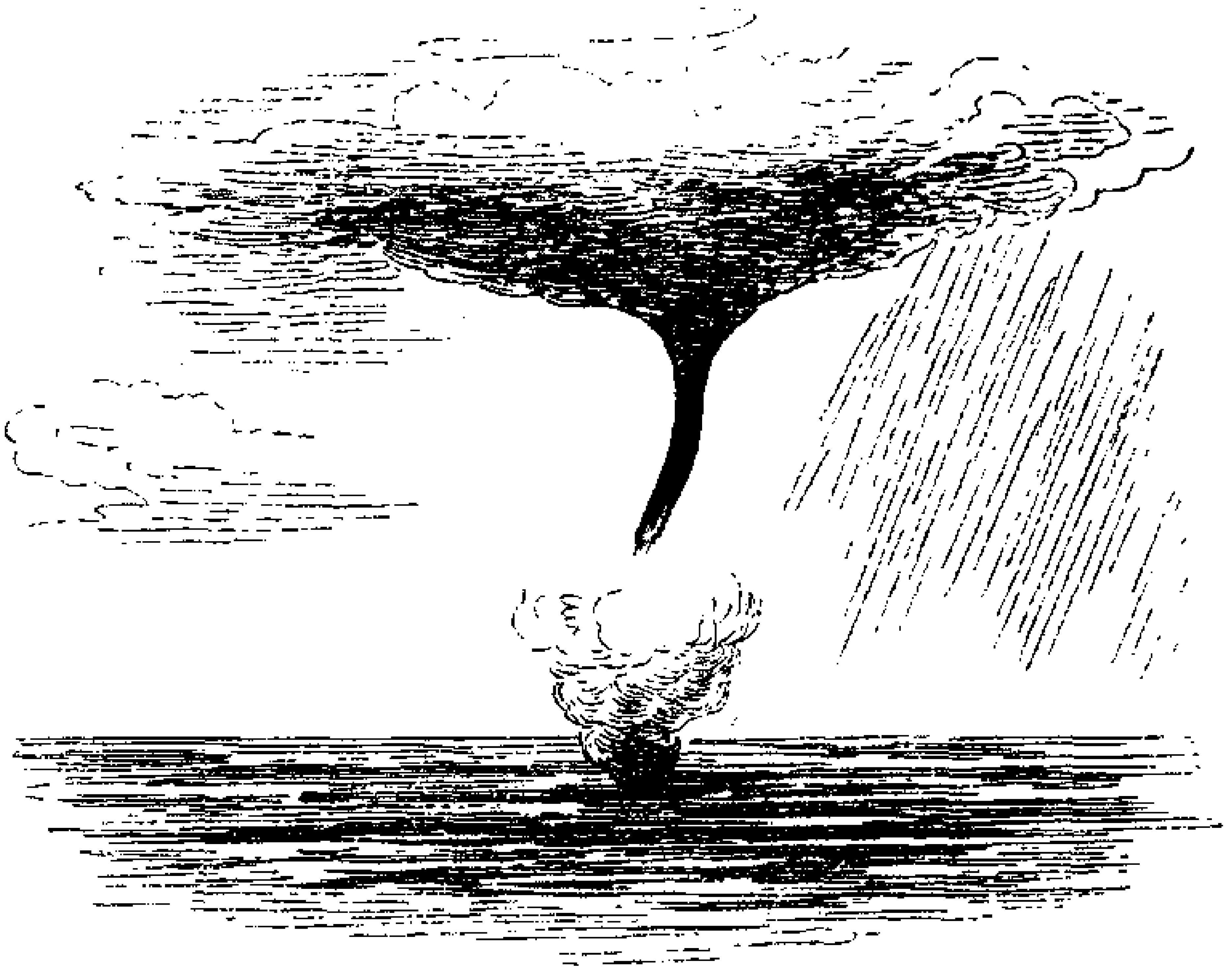
which is thus sometimes raised to a height of several hundred feet.

Water-spouts seldom last longer than half-an-hour. Their



course and movements are irregular; straight forwards; in zig-zag lines; alternately rising and falling; stationary; slow; or progressing with the rapidity of thirty miles an hour. The ro-

tatory movement is also variable; its power is often very great, but sometimes water-spouts pass over small vessels without in-



juring them. They are more frequent near the coast than on the high seas; and are more commonly seen in warm climates. They seem to occur particularly in regions where calms frequently alternate with storms, which is not to be wondered at, since they owe their origin to miniature storms or whirlwinds.

How do the aqueous vapours with which evaporation impregnates the atmosphere, again descend upon the surface of the earth?

Everybody knows that when in summer a bottle filled with cold water is brought into the room, it soon gets covered with thick dew-drops, which presently trickle down its sides, although it was perfectly dry on entering. Whence does this moisture come from? Not from the inside of the bottle as ignorant people might imagine, but from the surrounding atmosphere; in consequence of the capacity of the air to absorb and retain moisture, increasing or diminishing, as its temperature grows warmer or colder.

Thus when the cold bottle is introduced into the room, the warm sheet of air, which is in immediate contact with its surface, immediately cools, and being no longer able to retain all the moisture with which it was impregnated, is obliged to deposit it on the sides of the vessel. This familiar example suffices to explain the formation of dew, rain, hail, snow, hoar-frost, and

all other atmospherical precipitations. They all result from the influence of some refrigerating cause upon the air; such as the passage of a warm current into a cooler region; the influx of a cold wind; a cold-radiating chain of high mountains; a forest, and so forth.

The very name of dew is refreshing, and calls forth a host of pleasing ideas, associated as it is with the memory of serene skies and sunny mornings. How beautiful are its diamonds glittering in all the colours of the rainbow, on verdant meads, or on the blushing petals of the rose. How suggestive of all that is lovely, pure, and innocent!

Poetry is of older date than prose, and bards have sung long before philosophers inquired. Thus, although the children of song from Homer and Theocritus to Byron and Wordsworth so frequently mention dew in their immortal strains, it is only in our time that its formation has been fully explained by Dr. Wells, who in a very ingenious and masterly essay on this subject, first proved that it results from the ground radiating or projecting heat into free space, and consequently becoming colder than the neighbouring air. During calm and clear nights, the upper surfaces of grass-blades, for instance, radiate their caloric into the serene sky, from which they receive none in return. The lower parts of the plant, being slow conductors of heat, can only transmit to them a small portion of terrestrial warmth, and their temperature consequently falling below that of the circumambient atmosphere, they condense its aqueous vapours. Clouds on the contrary compensate for the loss of heat the grass sustains from radiation, by reflecting or throwing back again upon the terrestrial surface, the caloric which would else have been dissipated in a clear sky, and this is the reason why dew does not fall, or but slightly falls during clouded nights. It is easy to conceive why none is formed in windy weather, as then the air in contact with the ground is constantly removed ere it has time to cool so far as to compel it to part with its moisture. We can also understand why dew is more abundant in autumn and spring than at any other season; as then very cold nights frequently follow upon warm days; and why it is most copious in the torrid zone, as in those sultry regions the air is more saturated with moisture than anywhere else, and the comparatively cold nights are almost constantly serene and

calm. Hoar-frost is nothing but congealed dew, and owes its formation to the same causes.

When warmer air-currents are cooled by being transported into colder regions, or from any other refrigerating cause, a great part of their moisture generally condenses into small vesicles, but very little heavier than the surrounding atmosphere, which then becomes visible under the form of clouds, those great beautifiers of our changing skies, that frequently trace such picturesque, gorgeous, or singular groups and landscapes in the aërial regions. The inhabitants of countries where the heavens are monotonously serene, may well envy us the charms of a phenomenon which in some measure affords us compensation for so many disagreeable vicissitudes of the weather. Who that has admired at sunset the light clouds so beautifully fringed with silver and gold, or glowing with the richest purple, and loves to follow them in all their wonderful and fantastic transformations, will deny that they are the poesy and life of the skies, the awakeners of pleasing fancies and delightful reveries?

Thin wreaths of clouds have been observed, by travellers that have ascended the most elevated mountains, floating high above the peak of Chimborazo or Dhawalagiri, and thus shows us to what an amazing altitude the emanations of ocean are carried by the ascending air-current.

Sometimes when light clouds pass into a warmer atmosphere, they gradually dissolve and vanish; more frequently the accumulating moisture, too heavy to continue floating in the air, or condensed by electrical explosions, descends upon the earth in rain, which, with few exceptions, visits every part of the globe, either in its liquid form or congealed to snow or hail. But the quantity of rain which annually falls in different regions is very unequal, and strange to say, it is not most considerable in those countries whose climate enjoys an unenviable notoriety for its clouded atmosphere and the great number of its rainy days. In the tropical regions it is generally only about the time of the summer solstice that abundant showers of rain fall regularly every afternoon, while the rest of the year, the sky is uninterruptedly serene; but during the short period of the rainy season, a far greater quantity of water is precipitated upon the earth, than in the temperate zones.

While on the island of Guadaloupe, the annual quantity of

rain amounts to 274·2 French inches, and to 283·3 at Mahabuleshwar, on the western declivity of the Ghauts, which, as far as has hitherto been ascertained, is the place where most rain descends; only from 35 to 40 inches fall on the western coast of England, where the skies are chronically weeping.

It is a remarkable circumstance that the annual quantity of rain which falls in the same place remains about the same from year to year; so that by an admirable balancing of conflicting influences, nature seems to have provided for stability in a province which of all others might be supposed most open to the caprices of chance.

Having thus followed the exhalations of ocean to the end of what may be called the first stage of their journey, and seen them descend in a condensed form upon the surface of the dry land, I will now accompany them in their ulterior progress to the bosom of the seas. A great part of them have many transformations and changes to undergo ere they can accomplish their return; repeatedly rising in vapours from the solid earth, and falling in showers upon its surface; or circulating through the tissues of organic life: but after all these intermediate stages and delays, they ultimately find their way into rivulets or streams, which after many a meander restore them to the vast reservoir from which they arose.

The waters that descend upon solid rocks, or fall in large quantities upon abrupt declivities, immediately flow into the brooks or rivers; but when they gently and gradually alight upon a porous soil, they are absorbed by the earth, and, displacing in virtue of capillary attraction, and of their superior weight, the air which fills the interstices between its solid particles, sink deeper and deeper until they meet with a solid and impenetrable stratum. If this forms a hollow basin, they naturally settle in the cavity; whence they are slowly displaced by fresh accessions and evaporation; but if its deepest declivity lies somewhere near the surface, they gradually gush forth under the form of sources or springs, having unequal distances to perform before they can reach the orifice. If no fresh supply of water falls, ere the most distant particles have reached their journey's end, the source dries up: but if new atmospheric precipitations continually take place, the source is perennial, although naturally of unequal strength at different times.

The temperature of springs varies from icy coldness to boiling heat. Cold springs arise when the waters, by which they are fed, descend from high mountains or do not penetrate a great way into the bowels of the earth; but if the filtering waters reach a depth which is constantly of a higher temperature, they then gush forth in the form of warm or even boiling springs.

A crowd of agreeable associations attaches itself to the idea of sources and springs, for they are generally both pleasing and useful to man. How we long in summer for the refreshing waters of the cool fountain issuing from the mountain side, and murmuring through the woods. The lover of nature spends hours near some solitary spring, and forgets the flow of time, as he observes the bubbling and listens to the sweet music of its crystal waters. A luxuriant vegetation marks their progress, though all around be burnt up by the scorching sun. Along their margin many a wild flower blooms, and herbs and shrubs and trees rejoice in a more vivid green, and statelier growth. There also congregate such members of the finny race, as delight in cooler streams of untainted purity, and birds love to build their nests among the sheltering foliage. Thus a little world forms around the gushing spring, and shows on a diminutive scale, how all that lives and breathes depends upon the liquid element for its existence.

While the waters filter through the earth they naturally dissolve a variety of substances, and all springs are more or less mixed with extraneous particles. But many of them, particularly such as are of a higher temperature and consequently arise from deeper strata, contain either a larger quantity or so peculiar a combination of mineral substances as to acquire medicinal virtues of the highest order, and to become objects of importance to a large portion of mankind. Numberless invalids annually flock to the hygeian fountains which nature unceasingly pours forth from her mysterious laboratory, and are by them restored to the enjoyments of a pleasurable existence.

How truly wonderful is the chain of processes which first raises vapours from the deep, and eventually causes them to gush forth from the entrails of the earth, laden with blessings and enriched with treasures more inestimable than those the miner toils for!

Although a river generally has its source in mountainous regions, it must be remembered that all the waters that descend upon the territory of which it forms the lowest level, gradually find their way into its current. Thus, the monarch of all streams, the Amazon River, is the natural drain of a territory thirty times larger than England. Thousands of rivulets and brooks, fed by the waters which descend from the slopes of thousands of glens and valleys, or filter through the vast forest-plains that rise but a few feet above their surface, all contribute to swell the majesty of its current. Its sources are in reality wherever, on that vast extent of land, water descends and drains into any one of its innumerable affluents. When we hear that on an average the river of the Amazons alone restores every minute half a million of tons of water to the ocean, and then consider the countless number of streams all alike active, that are scattered over the globe, we may form a faint idea of the vast quantity of vapours which are constantly rising from the deep, and of the magnitude of these silent operations of nature. Yet such is the immensity of ocean, that supposing all the waters it constantly loses, never to return again into its bosom, it would require thousands of years of evaporation to exhaust the immensity of its reservoirs!

It might be supposed that the waters which congeal on the sides of mountains covered with perennial snow, or fill Alpine valleys in the form of glaciers, were eternally fixed on earth—but there also we are deceived by delusive appearances of immobility. Every year the glacier slowly but restlessly makes a step forwards into the valley, and while its lower end dissolves, new supplies of snow constantly feed it from above. It has been calculated by Agassiz that the ice masses of the Aar glacier require 133 years to perform their descent from its summit to its inferior extremity—a distance of ten miles—so that their sojourn in that chilled valley far surpasses that of the oldest patriarch of the mountains. How great must be their delight when they at last are liberated from the spell which so long enchained them, and freely bound along on their way to Ocean! How they must shudder at the idea of once more returning to their desolate prison, and long for the perpetual warmth of spicy groves and tropical gardens!

In the colder regions of the earth, in Greenland or Spitz-

bergen, immense glaciers frequently fill the valleys that open on the sea, descend even beyond the water's edge, and, as they move along, their overhanging masses separate from their base and plunge into the deep with a crash louder than thunder. The icebergs that drift about the Arctic seas, and are annually conveyed by the currents into lower latitudes, are formed in this manner. Huge blocks of granite, detached by atmospherical vicissitudes from the higher mountains and precipitated on the surface of the glaciers, frequently float on the broad back of an iceberg far away from the spot where they seemed rooted for eternity. As their crystal support melts away in its progress to warmer climes, these rocky fragments, which have been appropriately named *erratic blocks,* fall to the bottom of the sea hundreds or even thousands of miles from the starting point of their journey. Thus the great bank of Newfoundland is covered with stones from distant Greenland, raised high in the air by volcanic power myriads of years ago, and now condemned to an equally long repose below the surface of ocean. When will they rise again above the waters, and what further changes will they have to undergo ere their compacted atoms resolve themselves into dust and assume new forms? But, however remote their dissolution, it will inevitably come, for Time is all-powerful, and has an eternity to work out his changes.

The large blocks of stone that so wonderfully migrate on the wandering iceberg form but a small and insignificant portion of the terrestrial spoils which are transported to ocean by the returning waters. Every river is more or less laden with earthy particles which its current carries onwards to the sea and deposits at its mouth. In course of time their accumulation, as I have already mentioned, forms large tracts of fertile territory encroaching upon the maritime domains.

I shall end with a few words on the influence of forests in attracting or retaining the atmospherical moisture, as it is a subject of great importance in the economy of nations, and shows us how much it is in the power of man to improve or to defeat the provisions of nature in his favour.

Forests always cool the neighbouring atmosphere, for their foliage offers an immense warmth-radiating surface, so that the vapours readily condense above them and descend in frequent showers. At the same time their roots loosen the soil, and the

successive falling of their leaves forms a thick layer of humus, which has an uncommon power in attracting and retaining moisture. Their thick canopy of verdure also prevents the rays of the sun from penetrating to the ground, and absorbing its humidity. Thus the soil on which forests stand is constantly saturated with water, and becomes the parent of perennial sources and rills, that spread fertility and plenty far from the spot where they originated.

The rain-attractive influence of forests did not escape the attention of Columbus, who ascribed the frequent showers which refreshed and cooled the air, as he sailed along the coasts of Jamaica, to the vast extent and density of the woods that covered the mountains of that island. On this occasion he mentions in his journal that formerly rain had been equally abundant on Madeira, the Canaries, and the Azores, before their shady forests were felled or burnt by the improvident settlers.

The wanton destruction of woods has entailed barrenness on countries renowned in former times for their fertility. The mountains of Greece were covered with trees during the great epoch of her history, and the well-watered land bore abundant fruits, and sustained a numerous population. But man recklessly laid waste the sources of his prosperity. Along with the woods, many brooks and rivulets disappeared, and ceased to water the parched plains. The rain gradually washed the vegetable earth from the sides of the naked hills, and condemned them to sterility. When the snow of the mountains began to thaw under the warm breath of spring, it was now no longer retained by the spongy soil of the forests, and gradually dissolved under their cover; but, rapidly melting, filled with its impetuous torrents the bed of the rivers, and overflowing their banks, spread ruin and devastation far around.

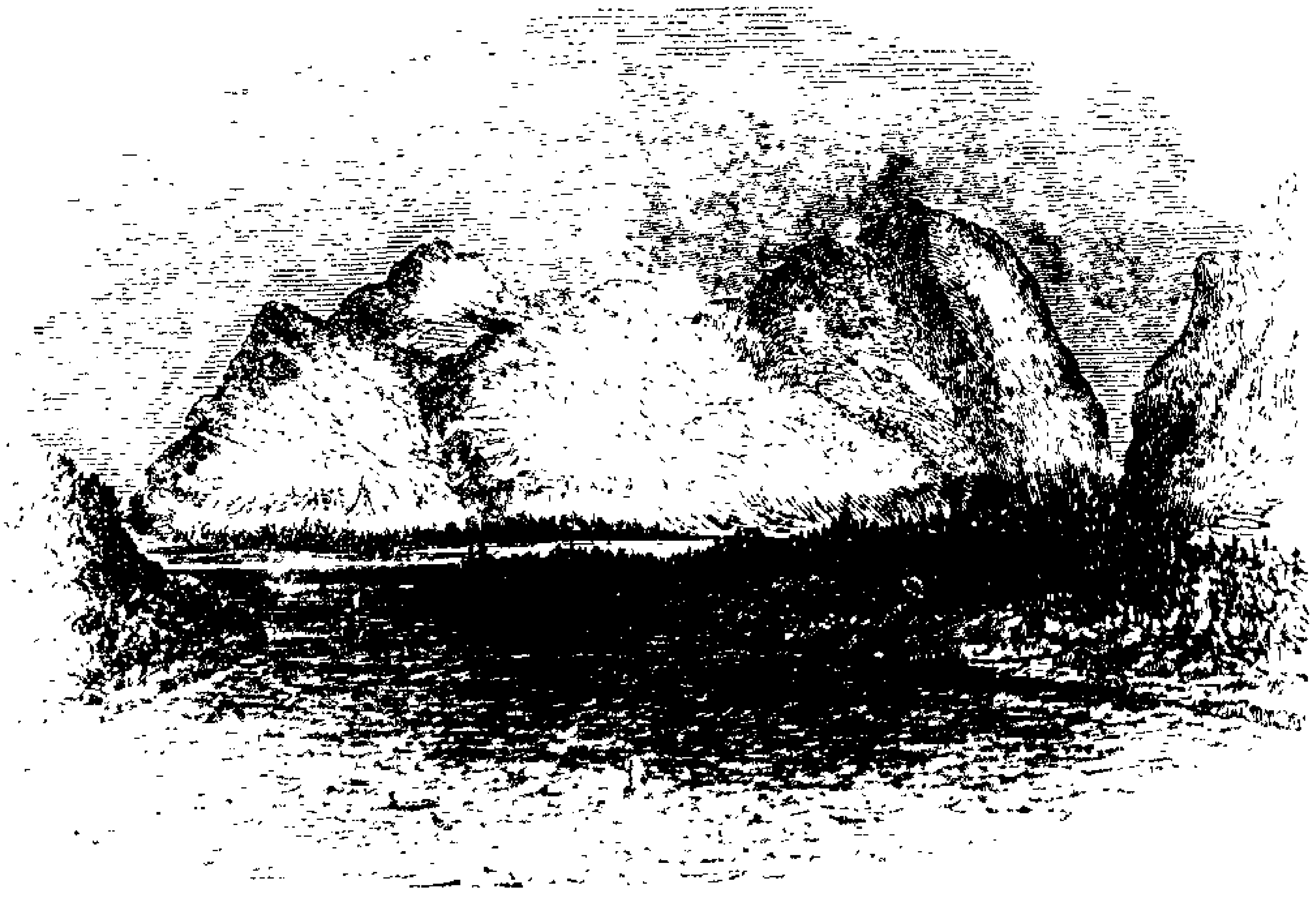
Unfortunately, forests when once destroyed are not so easily restored, and it requires many centuries ere the bared mountain side reassumes its pristine vesture of shady woods. First lichens, mosses, and other thrifty herbs, content to feed upon nothing, have to prepare a scanty humus for the reception of more pretentious guests. In course of time some small stunted shrub makes its appearance here and there in some peculiarly favoured spot, and after all requires vast powers of endurance to maintain itself on the niggard soil, exposed to the full enmity

of wind and weather. This paves the way for a more vigorous and fortunate offspring; and as every year adds something to the vegetation on the mountain's side, and opposes increasing obstacles to the winds, the falling leaves and decaying herbage accumulate more and more, until dwarfish trees first find a sufficiency of soil to root upon, and finally, the proud monarch of the forest spreads out his powerful arms and raises his majestic summit to the skies.

While Greece and Asia Minor have seen their fertility decrease or vanish with the trees that once covered their hills, other countries have improved as their vast woods have been thinned by the axe of the husbandman. In the time of the Romans all Germany formed one vast and continuous forest, and its climate was consequently much more rigorous than it is at present. All the low grounds were covered with impervious morasses, and the winter is described by historians in terms like those we should employ to paint the cold of Siberia.

But the scene gradually changed as tillage usurped the sylvan domain. The excessive humidity of the soil diminished, the swamps disappeared, and the heat of the sea, penetrating into the bosom of the earth, developed its productive powers. Thus the chestnut and the vine now thrive and ripen their fruits on the banks of the Rhine and the Danube, where 2000 years ago they could not possibly have existed. But Germany would also see her fertility decline, if the destruction of the forests which still crown the brow of many of her hills should continue in a considerable degree. Numerous rivulets would then be dried up during the warm season, in consequence of the more rapid descent and thaw of vernal rains and wintry snows, and most likely, refreshing summer showers would be far less frequent. Even now the inundations which almost annually desolate the banks of the Elbe, the Oder, and the Rhine, are ascribed by competent judges to the excessive clearing of the forests in the mountainous countries where those rivers originate. These few examples suffice to prove to us the power of man in modifying the climates of the earth, and the vast importance of the study of terrestrial physics. By planting or destroying woods, he is able to compel nature to a more equitable distribution of her gifts. In marshy and low countries, he may remove the surperfluous waters by drainage, and increase the productiveness of arid plains by

judicious irrigation. Thus man is the lord and master of the earth; but hitherto he has done but little to reap all the advantages he might have obtained from his dominion, or even used it to his own detriment. Drainage, irrigation, and a judicious management of forest-lands, are only beginning to be understood even among the most enlightened nations. A great part of our damp island still remains undrained, and we allow the rivers of India to pour their waters into the sea, instead of diverting them upon her thirsty plains. But there can be no doubt that as knowledge increases, man will gradually learn to provide every soil with the exact measure of humidity that is requisite to make it bring forth its fruits in the greatest abundance. Views such as these teach us, that, far from having attained the summit of civilisation, we are still on the threshold of her temple, and that most likely our descendants will look down upon our present condition as we do upon that of our barbarous ancestors.



Rocky Mountains at the bend of Bear Lake River.

CHAP. VII.

MARINE CONSTRUCTIONS.

Lighthouses.—The Eddystone.—Winstanley's Lighthouse, 1696.—The Storm of 1703.—Rudyerd's Lighthouse destroyed by Fire in 1755—Singular Death of one of the Lighthouse Men.—Anecdote of Louis XIV.—Smeaton.—Bell Rock Lighthouse.—History of the Erection of Skerryvore Lighthouse.—Illumination Lighthouses.—The Breakwater at Cherbourg.—Liverpool Docks.—The Tubular Bridge over the Menai Straits.—The Sub-oceanic Mine of Botallack.

In one of the finest passages of "Childe Harold," Byron contrasts the gigantic power of the sea with the weakness of man. He describes the resistless billows contemptuously playing with the impotent mariner—now heaving him to the skies, now whelming him deep in the bosom of the tumultuous waters; he mocks the vain pride of our armadas, which are but the playthings of ocean, and points with a bitter sneer at the wrecks with which he strews his shores. A less misanthropic mood or a more truthful view of things might have prompted the wayward poet to celebrate the triumphs of man over the brute strength of the winds and waves; how, guided by the compass, he boldly steers through the vast waste of waters, how he excavates the artificial harbour, or piles up the breakwater to protect his bark against the destructive agencies of the billow and the storm, or how he erects the lighthouse to point out the neighbourhood of dangerous shoals or the entrance of the friendly port.

The various constructions planned and executed by man to disarm the turbulent or perfidious seas of a great part of their terrors, are indeed among the noblest monuments of his architectural genius, nor are any more deserving of universal applause and gratitude. Who has ever performed a winter voyage homewards over the wide Atlantic and not felt a thrill of delight when the first bright flash of light beamed over the dark waters and welcomed him back to his native isle? or what generous mind has ever experienced this feeling without devoting the

tribute of its thanks to the wise and beneficent men whose energy and perseverance have succeeded in lighting every head land or estuary of our rugged coast? So completely has this been done, that in the dark and stormy night, almost as well as in the brightest day, the homeward-bound ship need not approach danger without receiving friendly warning, for her pathway is illuminated by gigantic fire-beacons so thickly set that when one fades to the sight a new one rises to the view.

Among the numerous lighthouses with which the genius of humanity has encircled our native shores, the Eddystone, the Bell Rock, and the Skerryvore, are pre-eminent for the vast difficulties that had to be surmounted in their construction, situated as they are upon solitary rocks, exposed to the full fury of the insurgent waves; and should by some revolution all other monuments erected by man be swept away from the surface of our land, and these alone remain, they would suffice to testify to future ages that these islands were once inhabited by a highly civilised and energetic race, one well worthy to lay claim to the dominion of the seas.

At the distance of about twelve miles and a half from Plymouth Sound, and intercepting, as it were, the entrance of the Channel, the Eddystone rocks had been for ages a perpetual menace to the mariner. The number of vessels wrecked on these perfidious shoals must have been terrible indeed, it being even now a common thing in foggy weather for homeward-bound ships to make the Eddystone Lighthouse as the first point of land of Great Britain, so that in the night and nearly at high water, when the whole range of the rocks is covered, the most careful pilot might run his ship upon them, if nothing was placed there by way of warning. As the trade of England increased, the number of fatal accidents naturally augmented, rendering it more and more desirable to crest the Eddystone with a tutelary beacon; yet years elapsed before an architect appeared bold enough to undertake the task. At length, in 1696, Mr. Winstanley, a country gentleman and amateur engineer, made the first attempt of raising a lighthouse on those sea-beaten rocks, but as he was possessed of more enterprise than solid knowledge, the structure he erected was deficient in every element of stability. Yet such was the presumption of the man that he was known to express a wish that the fiercest storm that ever blew might arise to test the

solidity of the fabric. The elements took him at his word, for while on a visit of inspection to his lighthouse the dreadful storm of November 26, 1703, arose, the only storm which in our latitude has equalled the rage of a tropical hurricane. "No other tempest," says Macaulay in his Essay on Addison, "was ever in this country the occasion of a Parliamentary address or of a public fast. Whole fleets had been cast away. Large mansions had been blown down. One Prelate had been buried beneath the ruins of his palace. London and Bristol had presented the appearance of cities just sacked. Hundreds of families were still in mourning. The prostrate trunks of large trees and the ruins of houses still attested in all the southern counties the fury of the blast." No wonder that a tempest like this swept away the ill-constructed lighthouse like the "unsubstantial fabric of a vision," and that neither poor Mr. Winstanley nor any of his companions survived to recount the terrors of that dreadful night.

Strange to say, the task of rebuilding the Eddystone lighthouse, which was now felt as a national necessity, once more devolved, not upon a professed architect, but upon a Mr. Rudyerd, a linendraper of Ludgate Hill, the son of a Cornish vagrant, who had raised himself by his talents and industry from rags and mendicancy to a station of honourable competence. The choice, however, was not ill made, for, with the assistance of two competent shipwrights, the London tradesman constructed an edifice which, though mainly of timber, was so firmly bolted to the rock with iron branches that for nearly half a century it resisted the fury of the billows, and might have withstood them for many a year to come had it not been rapidly and completely destroyed by fire. This catastrophe, which happened on December 2, 1755, was marked by a strange accident, for while one of the light-keepers was engaged in throwing up water four yards higher than himself, a quantity of lead, dissolved by the heat of the flames, suddenly rushed like a torrent from the roof, and falling upon his head, face, and shoulders, burnt him in a dreadful manner. Having been conveyed to the hospital at Plymouth, he invariably told the surgeon who attended him, that he had swallowed part of the lead while looking upward; the reality of the assertion seemed quite incredible, for who could suppose it possible that any

human being could exist after receiving melted lead into the stomach, much less that he should afterwards be able to bear the hardships and inconvenience from the length of time he was in getting on shore before any remedies could be applied. On the twelfth day, however, the man died, and having been opened a solid piece of lead, which weighed above seven ounces, was found in his stomach.*

Another interesting anecdote is attached to the history of Rudyerd's lighthouse. Louis XIV. being at war with England while it was being built, a French privateer took the men at work upon it and carried them to France, expecting, no doubt, a good reward for the achievement. His hopes, however, were doomed to a grievous disappointment, for while the captives lay in prison, the transaction reached the ears of the monarch, who immediately ordered them to be released and the captors to be put in their place; declaring that though he was at war with England, he was not at war with mankind. He therefore directed the men to be sent back to their work with presents; observing that the Eddystone lighthouse was so situated as to be of equal service to all nations navigating the Channel. It is gratifying to meet with this trait of natural generosity in a mind long since obscured by the bigotry which prompted the revocation of the Edit de Nantes.

After these repeated disasters, the rebuilding of Eddystone lighthouse, in a more substantial manner than had hitherto been effected, was now no longer confided to amateur ingenuity, but to John Smeaton, an eminent civil engineer, one of those men who by originality of genius and strength of character are so well entitled to rank among the worthies of England. From his early infancy Smeaton (born May 28, 1724) gave tokens of the extraordinary abilities which were one day to render his name illustrious. Before he attained his sixth year his playthings were not the playthings of children but the tools which men employ: before he was fifteen he made for himself an engine for turning, forged his iron and steel, and had self-made tools of every sort for working in wood, ivory, and metals. At eighteen he by the strength of his genius acquired the art of working in most of the mechanical trades, and such was his untiring zeal

* A full account of this extraordinary circumstance was sent to the Royal Society, and printed in vol. xlix. of their Transactions, p. 477.

that a part of every day was generally occupied in forming some ingenious piece of mechanism. In 1753, his various inventions and improvements had already attracted such notice that he was elected member of the Royal Society; and when, a few years later, the accident happened which burnt down the Eddystone lighthouse to the ground, he was at once fixed upon as the person most proper to rebuild it A better choice could not possibly

Eddystone Lighthouse.

have been made, for Smeaton's lighthouse, firm as the rock on which it stands, has now already braved the storms of more than a century, and will no doubt continue to brave them for many ages to come. Of him it may well be said "exegit monumentum ære perennius," for to him is due the honour of having fixed the *best form* to be given to a marine lighthouse, and even now the Eddystone beacon-tower remains a model which has hardly been surpassed by the taller and more graceful edifices of Bell Rock

and Skerryvore. Nothing could exceed the patient ingenuity, the sagacity, and forethought with which that great engineer mortised his tall tower to the wave-worn rock, and then dovetailed the whole together, so as to make rock and tower practically one stone, and that of the very best form for deadening the action of the wave. Nor must we forget that our great marine lighthouses, of which Smeaton gave the model, are as remarkable from an artistic as from a utilitarian point of view, as pleasing to the man of taste as to the friend of humanity. "It is to be regretted," says, with perfect justice, the author of an excellent article in the Quarterly Review,* "that these structures are placed so far at sea that they are very little seen, for they are, taken altogether, perhaps the most perfect specimens of modern architecture which exist. Tall and graceful as the minar of an Eastern mosque, they possess far more solidity and beauty of construction; and, in addition to this, their form is as appropriate to the purposes for which it was designed as anything ever done by the Greeks, and consequently meets the requirements of good architecture quite as much as a column of the Parthenon."

Covered to the height of fifteen feet at spring tide, and little more than a hundred yards in its extent, the famous Bell Rock, or Inchcape, facing the Frith of Tay at a distance of twelve miles at sea, was as dangerous to the navigation of the eastern coast of Scotland as the Eddystone had been to the entrance of the Channel. To erect a tower on a spot like this was an undertaking of no common boldness, but, fired by Smeaton's example, Mr. Robert Stevenson no less gloriously succeeded in converting what for ages had been a source of danger into a beacon of safety.

On the opposite coast of Scotland, and placed in the same parallel of latitude as Bell Rock, the Skerryvore Reef had a name equally dreaded by the mariner. Situated considerably farther from the mainland than the Bell Rock, it is less entirely submerged, some of its summits rising above the level of high water, though the surf dashes over them; but the extent of foul ground is much greater, and hidden dangers, even in fine weather, beset the intervening passage between its eastern extremity and Tyree, from which island it is distant some eleven miles. In rough weather the sea which rises there is described as one in which no ship

* No. 228.

could live. This terrible reef, so fatal to many a gallant bark, rendered the erection of a lighthouse most desirable, yet such was the difficulty of the case that although so long ago as 1814 an Act was obtained for a light on Skerryvore, it was not before 1837 than Mr. Alan Stevenson, son of the famous architect of the Bell Rock sea-tower, was authorised to commence the work. That difficulty was not confined to the position and character

Bell Rock Lighthouse.

of the reef itself, as the neighbouring island of Tyree afforded no resource, and all the materials for the building, even the stone itself, had to be transported from distant quarters. At length, all preliminary arrangements being settled, the engineer reached the rock and commenced his work, in June 1838, by erecting a barrack-house upon stilts—a sort of dovecot perched on poles—high out of the water on the reef, close to the proposed site of the lighthouse. The erection of this barrack fully occupied the

first summer; and, lest it might be supposed that this was but little work for so long a time, it may be as well to remark that, such was the turbulence of the sea that between August 7 and September 11, it had only been possible to be 165 hours on the rock. Much inconvenience was occasioned by the hard and slippery nature of the volcanic formation of the Skerryvore, to which the action of the sea had given the appearance and the smoothness of a mass of dark-coloured glass, so that the foreman of the masons compared the operation of landing on it to that of climbing up the neck of a bottle. When we consider how often, by how many persons, and under what circumstances of swell and motion, this operation was repeated, we must look upon this feature of the spot as an obstacle of no slight amount.

At length, after much danger and difficulty, the barrack was completed, but the first November storm swept it away and utterly annihilated the work of the season. Iron stancheons had been drawn, broken, and twisted like the wires of a champagne bottle; the smith's iron anvil had been transported eight yards from where it was left; and a stone three-fourths of a ton was lifted out from the bottom of a hole and sent towards the top of the rock.

Mortified, but nothing daunted by this disaster, which gave him a warning of the tremendous power he had to contend with, Mr. Stevenson prepared during the winter for the labours of 1839, which, besides the re-erection of the barrack on an improved plan, chiefly consisted in the levelling or blasting of a flat surface of forty-two feet diameter on the top of the rock from which the lighthouse was to arise. This foundation pit was in itself a work of no small magnitude, as it required for its excavation the labours of 20 men for 217 days, the firing of 296 shots, and the removal into deep water of 2,000 tons of material. The blasting, from the absence of all cover and the impossibility of retiring to a distance farther in any case than thirty feet, and often reduced to twelve, demanded all possible carefulness.

The only precautions available were a skilful appointment of the charge and the covering the mines with mats and coarse netting made of old rope. Every charge was fired by or with the assistance of the architect in person, and no mischief occurred.

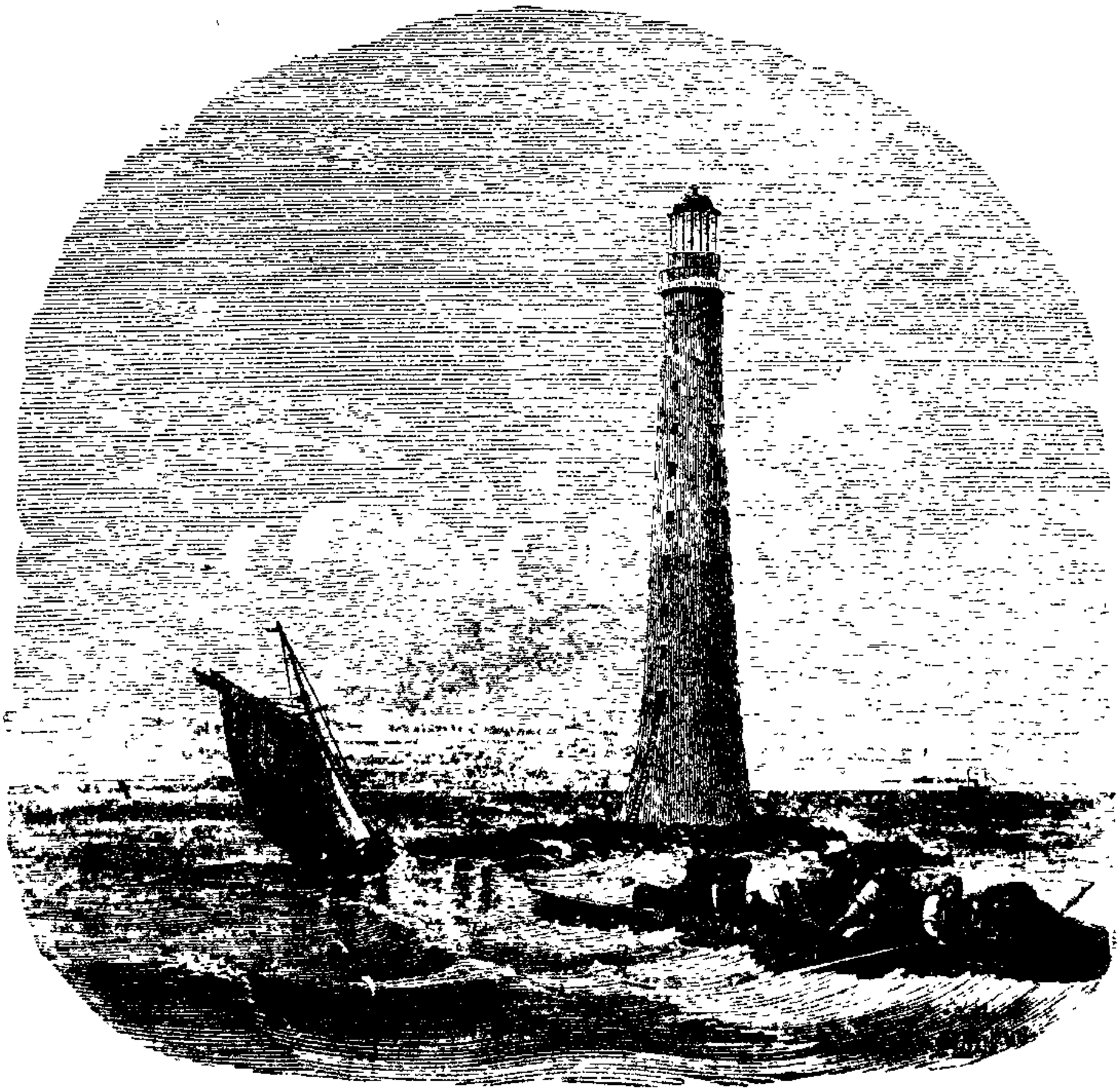
The year 1840 had now arrived, and the construction of the lighthouse was about to begin. Quarriers and labourers had been

busily employed in cutting blocks of stone in the quarries. Carpenters were diligently engaged in making wooden moulds for each lighthouse block wherewith to guage its exact mathematical figure. In April, a reinforcement of thirty-seven masons from Aberdeen arrived at Tyree—men expert in the difficult work of dressing granite—and, on April 30, the first visit was made to the rock. To the great joy of all, the barrack constructed in the previous season was found uninjured, though a mass of rock weighing about five tons had been detached from its bed and carried right across the foundation pit by the violence of the waves. In this barrack the architect and his party now took up their quarters, which from the frequent flooding of the apartments with water and from the heavy spray that washed the walls were anything but agreeable. "Once," says the gallant engineer,* "we were fourteen days without communication with the shore or the steamer, and during the greater part of that time we saw nothing but white fields of foam as far as the eye could reach, and heard nothing but the whistling of the wind and the thunder of the waves, which was at times so loud as to make it almost impossible to hear anyone speak. Such a scene, with the ruins of the former barrack not twenty yards from us, was calculated to inspire the most desponding anticipations; and I well remember the undefined sense of dread that flashed on my mind, on being awakened one night by a heavy sea which struck the barrack and made my cot swing inwards from the wall, and was immediately followed by a cry of terror from the men in the apartment above me, most of whom, startled by the *sound and the tremor*, sprang from their berths to the floor, impressed with the idea that the whole fabric had been washed into the sea."

This spell of bad weather, though in summer, well-nigh outlasted their provisions; and when at length they were able to make the signal that a landing would be practicable, scarcely twenty-four hours' stock remained on the rock. The landing of the heavy stones from the lighters was a work of no small difficulty, considering the slippery nature of the rock, and as the loss of one dressed stone would frequently have delayed the whole progress of the building, the anxiety was incessant. On July 4, the building of the tower really commenced. Six courses

* Account of Skerryvore Lighthouse, by Alan Stevenson, Engineer to the Northern Lighthouse Board. Edinburgh, 1848.

of masonry carried the building to the height of 8 feet 2 inches before the autumnal gales terminated the work of 1840, and an excellent year's work it was. The saying that "what is well begun is half done" was illustrated here. Next year's work was comparatively easy—so that in 1842 the tower rose to its full height of 138 feet, and the year after the light was shedding its



The Skerryvore Lighthouse.

beneficent rays over the thirty miles of watery waste that surround the hidden rocks of Skerryvore.

Well may we be proud of men like Smeaton and the Stevensons; but, while justly admiring their architectural skill, their perseverance, and their courage, we must not forget to offer the just tribute of our gratitude to the eminent natural philosophers without whose ingenious optical inventions the most splendid sea-towers would be comparatively useless. The Pharus or lighthouse of Alexandria was, probably with justice,

reckoned among the seven wonders of the world, and its several stories, rising on marble columns to the height of 400 feet, must have presented an imposing spectacle, but I strongly suspect that the rude brazier on the summit of the majestic pile bore the same proportion to the lighthouse lanterns of our time as the wretched coasting-craft of the ancient Greeks to the ocean steamers of the present day. Among the names of those who have contributed most effectually to the progress of marine illumination Argand, Borda, and Fresnel are conspicuous. The hollow cylindrical wick of the first was a sudden and immense advance in the art of economical and effective illumination. The second, by his invention of the parabolic mirror, multiplied the effect of the unassisted flame by 450, and the refracting lens of Fresnel so admirably concentrates the light as to project its warning beams to the wonderful distance of thirty or thirty-five miles

In former ages the efforts of man to provide a refuge to the mariner from the fury of the raging gale were feeble and insignificant. Content with the harbours that nature had provided, it was then thought quite sufficient to line a river-bank with quays or to enclose a natural pond by walls. The idea of raising colossal breakwaters by casting whole quarries into the deep, or of extending artificial promontories far into the bosom of the ocean, is of modern date, and would have appeared chimerical not only to the ancients but to our fathers not a century ago. The first great work of this description is the famous breakwater planned by De Cessart in 1783, and terminated in 1853, which has converted the open roadstead of Cherbourg into a land-locked harbour. Rising from a depth of 40 feet at low spring tides, on a coast where the floods attain a height of 19 feet, it opposes a front of 12,700 feet to the fury of the storm, and carries 250 pieces of the heaviest cannon on its formidable brow.

It far surpasses in extent and boldness of construction the breakwater at Plymouth, nor will it be eclipsed by the moles now forming at Portland, Holyhead, and Alderney; but although it is a more impressive spectacle to see man struggling with the ocean and producing calmness and shelter in the midst of the raging storm, than to contemplate his operations where he has no such adversaries to subdue, still such buildings as those just described are neither the largest nor the most expensive works

required for the accommodation of shipping. Witness the Cyclopean grandeur of the Liverpool docks or of the Great Float at Birkenhead, which alone covers an area of water of 121 acres, and whose portals, with a clear opening of 100 feet, will admit the largest screw-steamer or sailing ship the wildest imagination has yet conceived. Six millions of money is the cost of this one work alone—more than would be required to raise a pyramid like that of Cheops—and even this sum is a trifle when compared with what has been spent on the harbours of Liverpool, London, and other great commercial cities.

Not satisfied with erecting his lighthouses on wave-worn rocks or defying the waves with his colossal breakwaters, man spans bridges over arms of the sea and excavates mines under the abysses of the deep. The locomotive now rolls full speed 100 feet above high water over the strait which separates Anglesea from the mainland; and in Botallack and several other Cornish mines the workman, while resting from his subterranean labours, hears the awful voice of the ocean rolling over his head.

"In all these submarine mines," says Mr. Henwood, "I have heard the dashing of the billows and the grating of the shingle when in calm weather. I was once, however, underground in Wheal Cock during a storm. At the extremity of the level seaward some eighty or one hundred fathoms from the shore, little could be heard of its effects, except at intervals, when the reflux of some unusually large wave projected a pebble outward, bounding and rolling over the rocky bottom. But when standing beneath the base of the cliff, and in that part of the mine where but nine feet of rock stood between us and the ocean, the heavy roll of the large boulders, the ceaseless grinding of the pebbles, the fierce thundering of the billows, with the crackling and boiling as they rebounded, placed a tempest in its most appalling form too vividly before me ever to be forgotten. More than once doubting the protection of our rocky shield, we retreated in affright, and it was only after repeated trials that we had confidence to pursue our investigations." Yet the miners, accustomed from their early youth to the fierce and threatening roaring of the stormy sea, pursue their work from year to year, never doubting that the thin roof which separates them from a watery grave will continue to protect them, as it has shielded their fathers before them.

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PART II.

THE INHABITANTS OF THE SEA.

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CHAP. VIII.

THE CETACEANS.

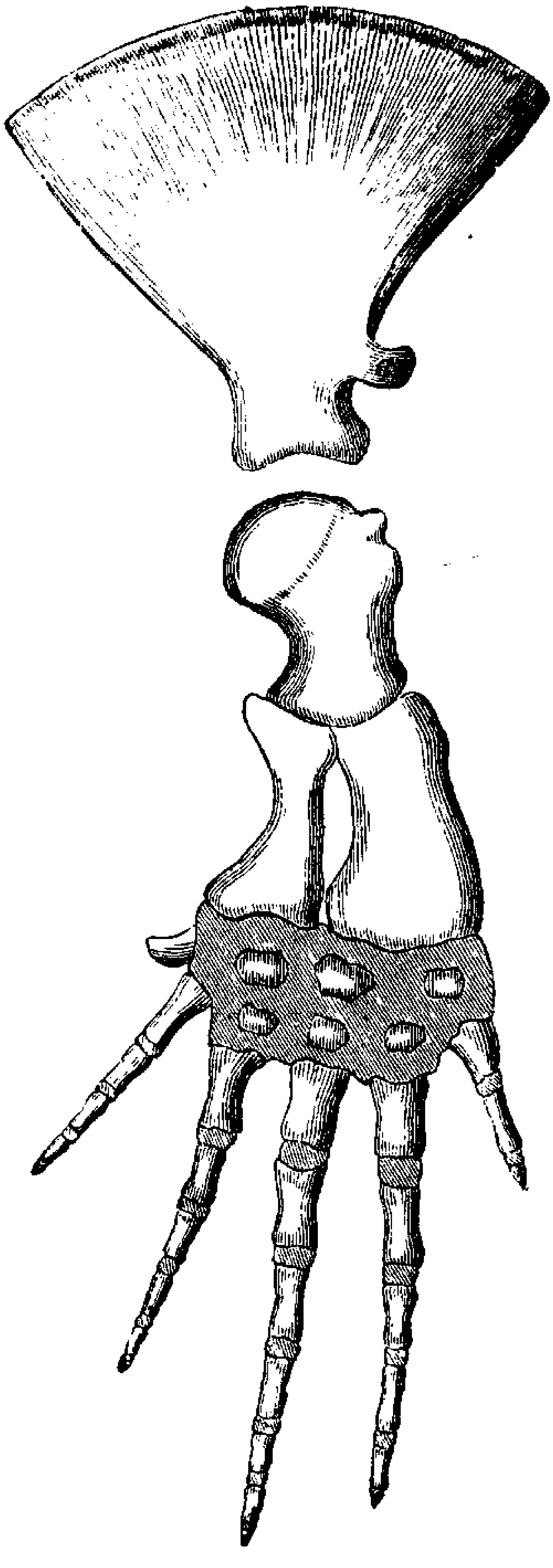
General Remarks on the Organisation of the Cetaceans.—The Large Greenland Whale.—His Food and Enemies.—The Fin-Back or Rorqual.—The Antarctic Whale.—The Sperm Whale.—The Unicorn Fish.—The Dolphin.—Truth and Fable.—The Porpoise.—The Grampus.—History of the Whale Fishery.

Of all the living creatures that people the immensity of ocean, the cetaceans, or the whale family, are the most perfect. Their anatomical construction renders them in many respects similar to man, and their heart is susceptible of a warmth of feeling unknown to the cold-blooded fishes; for the mother shows signs of attachment to her young, and forgets her own safety when some danger menaces her offspring. Like man, the cetaceans breathe through lungs, and possess a double heart, receiving and propelling streams of *warm* red blood. The anatomical structure of their pectoral fins bears great resemblance to that of the human arm, as the bony structure of those organs equally consists of a shoulder-blade, an upper arm, a radius and ulna, and five fingers.

But the arm, which in man moves freely, is here chained to the body as far as the hand, and the latter, which, in obedience to human volition and intellect, executes such miracles of industry and art, is here covered with a thick skin, and appears as a broad undivided fin or flapper. Yet still it is destined for higher service than that of a mere propelling oar, as it serves the mother to guide and shield her young. The lower extremities are of course wanting, but their functions are performed by the mighty *horizontal* tail, by whose powerful strokes the unwieldy animal glides rapidly through the waters.

The cetaceans distinguish themselves, moreover, from the fishes by the bringing forth of living young, by a greater quantity of blood, by the smoothness of their skin, under which is found a

thick layer of fat, and by their simple or double blow-hole, which is situated at the top of the head, and corresponds to the nostrils of the quadrupeds, though not for the purpose of smelling, but merely as an organ of respiration.



Bones of the Anterior Fin of a Whale.

Our knowledge of the cetaceans is still very incomplete; and this is not to be wondered at, when we consider that they chiefly dwell in the most inaccessible parts of the ocean, and that when met with, the swiftness of their movements rarely allows more than a flighty view of their external form. Thus their habits and mode of living are mostly enveloped in obscurity; and while doubtless many cetaceans are to the present day unknown, one and the same species has not seldom been described under different names, to the no small confusion of the naturalist.

The cetaceans are either without a dental apparatus, or provided with teeth. The former, or the whalebone whales, have two blow-holes on the top of the head, in the form of two longitudinal fissures; while in the latter, (sperm-whales, unicorn-fish, dolphins,) which comprise by far the greater number of species, there is but one transversal spout-hole. In all whales the larynx is continued to the spouting canal, and deeply inserted or closely imbricated within its tube. Thus no tones approaching to a voice can be emitted except through the spiracles, which are encumbered with valves, and evidently badly adapted for the transmission of sound. Scoresby assures us that the Greenland whale has no voice, and Bennett frequently noticed sperm

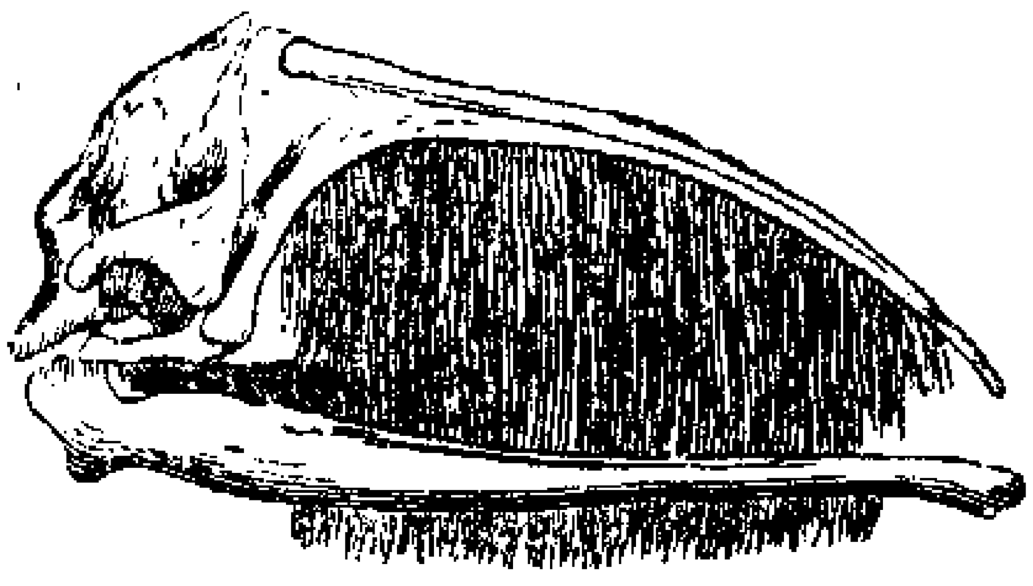
whales suffering from extreme alarm and injury, but never heard any sound from them beyond that attending an ordinary respiration.

The whalebone whales are either *smooth-backs* (Balænæ), or *fin-backs* (Balænopteræ), having a vertical fin rising from the lower part of the back. To the former belongs the mighty Greenland Whale (*Balæna mysticetus*), the most bulky of living animals, and of all cetaceans the most useful and important to man. Its greatest length, according to Scoresby, is from sixty to seventy feet, and round the thickest part of its body it measures from thirty to forty feet, but the incessant persecutions to which it is subjected scarcely ever allow it to attain its full growth.

The whale being somewhat lighter than the medium in which it swims, its weight may be ascertained with tolerable accuracy; and Scoresby tells us that a stout animal of sixty feet weighs about seventy tons, allowing thirty to the blubber, eight or ten to the bones, and thirty or thirty-two to the carcase. The lightness of the whale, which enables it to keep its *crown*, in which the blow-hole is situated, and a considerable extent of back above the water, without any effort or motion, is not only owing to its prodigious case of fat, but also to the lightness of its bones, most of which are very porous and contain large quantities of fine oil; an admirable provision of nature for the wants of a creature destined to breathe the atmospheric air, and to skim its food from the surface of the waters.

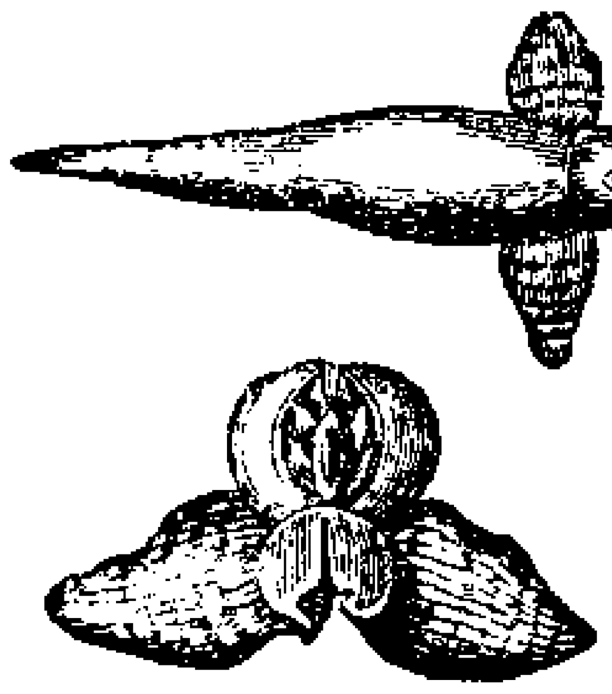
The unsightly animal shows disproportion in all its organs. While the tail fin measures twenty-four feet across, the pectoral fins or paddles are no more than six feet long. The monstrous head forms about the third of the whole body, and is furnished with an equally monstrous mouth, which on opening exhibits a cavity about the size of an ordinary ship's cabin. The leviathans of the dry land, the elephant, the rhinoceros, and the hippopotamus, are provided with tusks and teeth corresponding to their size—huge weapons fit for eradicating trees or crushing the bone-harnessed crocodile: but the masticatory implements of the giant of the seas are scarcely capable of dividing the smallest food. Instead of teeth, its enormous upper jaw is beset with about 500 laminæ of whalebone, ranged side by side, two-thirds of an inch apart, the thickness of blade included, and resembling a frame

of saws in a saw-mill. Their interior edges are covered with fringes of hair; externally they are curved and flattened down, so as to present a smooth surface to the lips. The largest laminæ, situated on both sides of the jaw, attain a length of fifteen feet, and measure from twelve to fifteen inches at their base; in front and towards the back of the mouth they are much shorter.


Skull of Whale, with the Baleen.

Besides these, there are suspended from the palate many other small laminæ of the thickness of a quill, a few inches long, and likewise terminating in a fringe. Thus the whole roof of the mouth resembles a shaggy fur, under which lies the soft and spongy tongue, a monstrous mass often ten feet broad and eighteen feet long.

This whole formation is beautifully adapted to the peculiar nourishment of the whale, which does not consist, as one might suppose, of the larger fishes, but of the minute animals, (*Medusæ*, *Entomostraca*, *Clio borealis*, and other pteropod molluscs,) with which its pasture-grounds in the northern seas abound. To gather food, it swims rapidly with open mouth over the surface; and on closing the wide gates, and expelling the foaming streams, the little creatures remain entangled by thousands in the fringy thicket as in a net; there to be crushed and bruised by the tongue into a savoury pulp. Fancy the vast numbers requisite to keep a monster of seventy tons in good condition.


Clio borealis.

The back of the whale is usually of a fine glossy black, marked with whitish rays, which have some resemblance to the veins of wood. This mixture of colours presents an agreeable appearance, especially when the back of the fish is illuminated with the rays of the sun. The under part of the trunk and of the lower jaw is of a dead white. The skin is about an inch thick, and covers a layer of fat of fifteen inches; a most excellent coat for keeping the whale warm and increasing its buoyancy, but at the same time the chief cause which induces man to pursue it with the deadly harpoon.

The usual march of the whale over the waters is rarely more than four miles an hour, but its speed increases to an astonishing rapidity when terror or the agonies of pain drive it madly through the sea.

In its sportive humours it is sometimes seen to spring out of the water, and to remain suspended for a moment in the air. On falling back again into the sea, high foam-crested fountains spout forth on all sides, and mighty waves propagate the tumult in widening circles over the troubled ocean. Or else it raises its bulky head vertically on high, so that the deceived mariner fancies he sees some black rock looming out of the distant waters. But suddenly the fancied cliff turns round and brandishes playfully its enormous flukes in the air, or lashes the waters with such prodigious power, that the sound rolls far away like thunder over the deserts of the ocean.

Strange to say, the giant is of so cowardly a nature, that the sight of a sea-bird often fills him with the greatest terror, and causes him to avoid the imaginary danger by a sudden plunge into the deep.

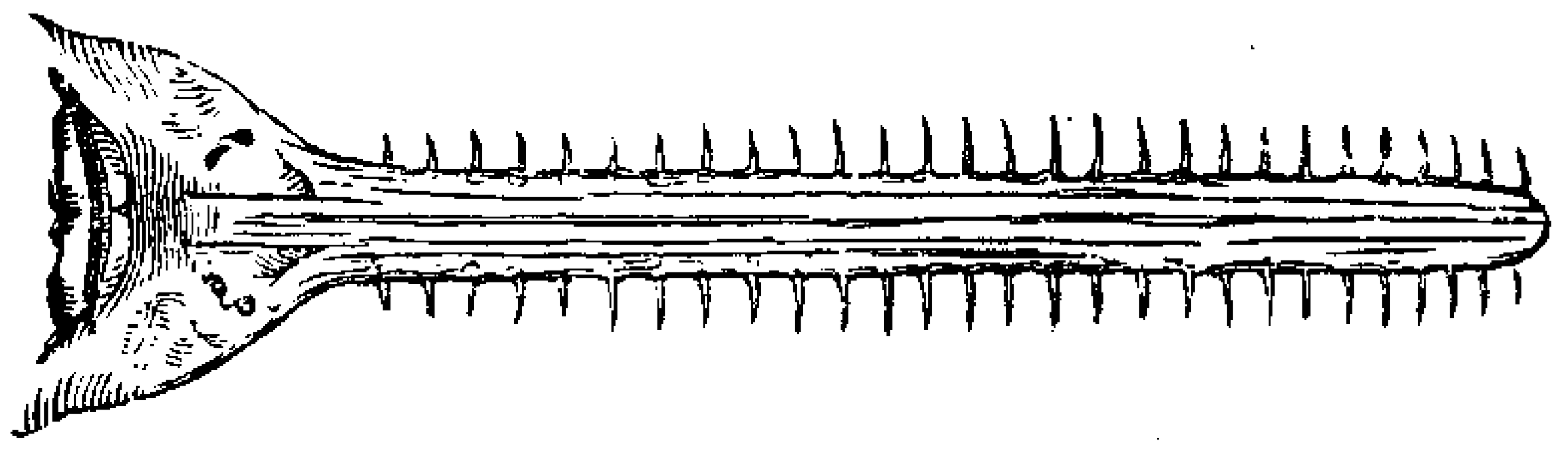
Besides man, a vast number of enemies, great and small, persecute the whale and embitter his life.

The Sword-fish (*Xiphias Gladius*) and the Thresher or Sea-fox, a species of shark (*Carcharias Vulpes*), often attack him conjointly and in packs. As soon as his back appears above the water, the threshers, springing several yards into the air, descend with great violence upon the object of their rancour, and inflict upon him the most severe slaps with their long tails, the sound of which resembles the report of distant musketry. The sword-fish, in their turn, attack the distressed whale, stabbing from below; and thus beset on all sides, and bleeding from countless wounds, the huge animal, though dealing the most dreadful blows with its enormous tail, and lashing the crimsoned waters into foam, is obliged to succumb at last.

The Greenland Shark (*Squalus borealis*) is also one of the bitterest enemies of the whale, biting and annoying it while living, and feeding on it when dead. It scoops hemispherical pieces out of its body nearly as big as a man's head, and continues scooping and gorging lump after lump, until the whole cavity of its belly is filled. It is so insensible of pain, that, though it has been run through the body, and escaped, yet after a while

Scoresby has seen it return to banquet again on the whale at the very spot where it received its wounds. The heart, as is frequently the case with gluttons, bears no proportion to its vast capacity of stomach; for it is very small, and performs only six or eight pulsations in a minute, continuing its beating for some hours after having been taken out of the body. The body also, though separated into any number of parts, gives evidence of life for a similar length of time. It is therefore so difficult to kill, that it is actually unsafe to trust the hand in its mouth though the head be separated from the body.

Strange to say, though the whale-fishers frequently slip into the water where sharks abound, Scoresby never heard an instance of their having been attacked by one of these voracious monsters. Perhaps they are loth to attack man, looking upon him as their best purveyor.



Saw of the Saw-fish.

Fishermen relate that the whale and saw-fish, whenever they come together, engage in deadly combat; the latter invariably making the attack with inconceivable fury.

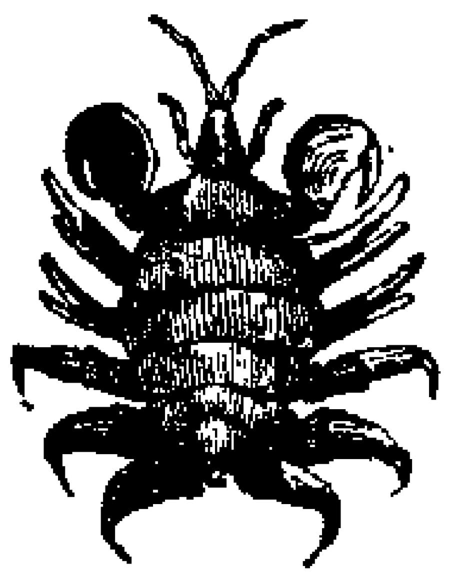
> "The meeting of these champions proud
> Seems like the bursting thunder cloud."

The whale, whose only defence is his tail, endeavours to strike his enemy with it; and a single blow would prove mortal. But the saw-fish, with astonishing agility, shuns the tremendous stroke, bounds into the air, and returns upon his huge adversary, plunging the rugged weapon with which he is furnished into his back. The whale is still more irritated by this wound, which only becomes fatal when it penetrates the fat; and thus pursuing and pursued, striking and stabbing, the engagement only ends with the death of one of the unwieldy combatants.

Even the white-bear is said to attack the whale, watching his

approach to the sea-shore; but the enmity of the narwhal is evidently fabulous, as both cetaceans may frequently be seen together in perfect harmony.

Besides these formidable attacks of what may be considered as more or less noble foes, the whale is constantly harassed by the bites of the vilest insects. A large species of louse adheres by thousands to its back, and gnaws this animated pasture-ground, so as to cover it frequently with one vast sore. In the summer, when this plague is greatest, numbers of aquatic birds accompany the whale, and settle on his back, as soon as it appears above the water, in order to feed upon these disgusting parasites.


Whale Louse

Barnacles often cover the whale in such masses, that his black skin disappears under a whitish mantle, and even sea-weeds attach themselves to his vast jaws, floating like a beard, and reminding one of Birnam's wandering forest.

As its name testifies, the home of the Greenland whale is confined to the high northern seas, where it has been met with in the open waters or along every ice-bound shore as far as man has penetrated towards the Pole. The southern limit of its excursions seems to be about 60° N. lat. It never visits the North Sea, and is seldom found within 200 miles of the British coasts. Its favourite resorts are the so-called whale-grounds,* between 74° and 80° N. lat., where the warmth, imparted to the water by the Gulf-stream, favours the multiplication of the small marine animals which form the nourishment of the Leviathan of the seas.

Sometimes open spaces in the ice, abounding in minute crustaceans and medusæ, attract a larger number of whales, but the huge creature cannot be said to live in larger herds or associations.

The Fin-fish or northern Rorqual (*Balænoptera boops, musculus*) attains a greater length than the sleek-backed Greenland whale, but does not equal it in bulk, having a more elongated form and a more tapering head. Its whalebone is much shorter and coarser, being adapted to a different kind of food, for, despising the minute medusæ and crustaceans which form the food of its huge relation, the more nimble rorqual pursues the herring

* See page 20.

and the mackerel on their wandering path. Like the blubber-whale, the fin-back is black above, white below, but distinguishes itself by long and numerous blood-red streaks or furrows, running under the lower jaw and breast as far as the middle of the belly. This is the species of whale which not unfrequently strands on our shores, for though an inhabitant of the Arctic seas, it wanders farther to the south than the Greenland whale. It is seldom harpooned, for the produce of oil is not equivalent to the expense, the risk, and the danger attending its capture.

In the southern hemisphere, the Antarctic Smooth-backed Whale (*B. antarctica*), a species similar to the Greenland whale, though of less bulk, is the chief object of the fisherman's pursuit. It hangs much about the coasts in the temperate latitudes, and loves the neighbouring seas, where the discoloured waters afford the richest repasts, but is not known in the central parts of the Pacific. In the spring it resorts to the bays on the coasts of Chili, South Africa, the Brazils, Australia, New Zealand, Van Diemen's Land, &c. &c., where it is attacked either by stationary fishermen, or by whalers, who at that time leave the high seas.

Farther towards the pole *Hump-backs* and *Fin-backs* abound; but these are far from equalling the former in value. When Dumont d'Urville, returning from his expedition to the south pole, told the whalers whom he found in the Bay of Talcahuano of the great number of cetaceans he had seen in the higher latitudes, their eyes glistened at the pleasing prospect; but when he added that they were only hump-backs and fin-backs, they did not conceal their disappointment; for the hump-back is meagre, and not worth the boiling, and the fin-back dives with such rapidity, that he snaps the harpoon line, or drags the boat along with him into the water.

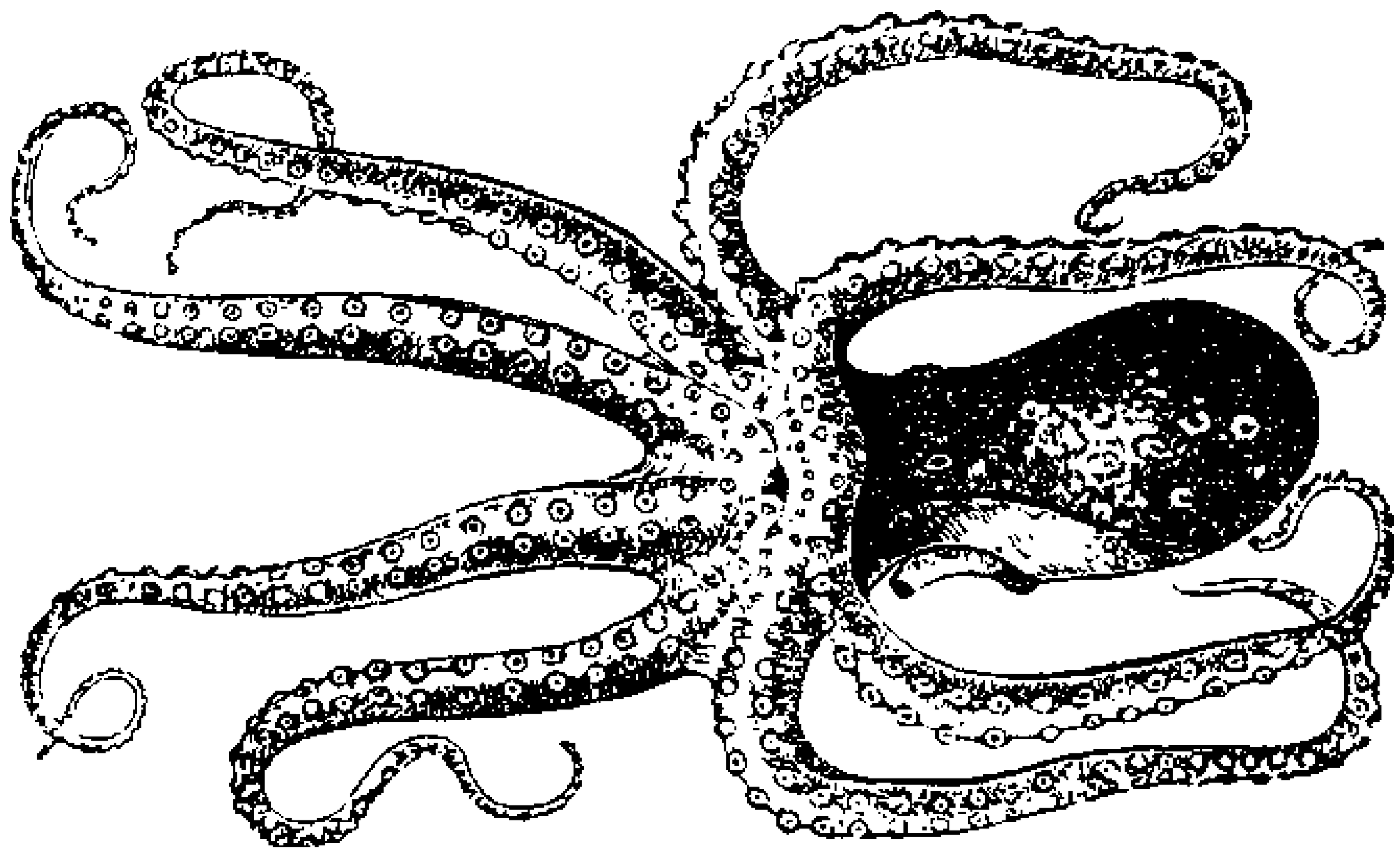
The Sperm Whale, or Cachalot (*Physeter macrocephalus*), rivals the great smooth-backed whales both in its various utility to man and the colossal dimensions of its unwieldy body. The largest authentically recorded size of the uncouth animal is seventy-six feet by thirty-eight in girth; but whalers are well contented to consider fifty-five or sixty feet the average length of the largest examples they commonly obtain. The male, however, alone attains these ample proportions; the adult female does not exceed thirty or at most thirty-five feet, so that there

is a greater disproportion of size between sexes than in any other known species of cetaceans.

The form of the beast is without symmetry, and from the general absence of other prominent organs than the tail or pectoral fins, can be compared to little else than a dark rock or the bole of some giant tree. The prevailing colour is a dull black, occasionally marked with white, especially on the abdomen and tail. The summit of the head and trunk presents a plane surface, until about the posterior third of the back, whence arises a hump or spurious fin of pyramidal form, and entirely composed of fat. From this embossed appendage an undulating series of six or eight similar, but smaller elevations, occupies the upper margin or ridge of the tail to the commencement of the caudal fin. The pectoral fins or paddles are placed a short distance behind the head; they are triangular in shape, diminutive as compared with the size of the whale, and being connected to the trunk by a ball and socket joint, possess free movement, either vertical or horizontal.

Owing to the flexibility of the tail, the movements of the tail-fin, or "flukes," which sometimes measures eighteen feet across, are exceedingly extensive, whilst its power may be estimated by the gigantic bundles of round tendons, which pass on either side the loins, to be inserted into its base. Whether wielded in sportive mood or in anger, its action is marked by rapidity and ease, and when struck forcibly on the surface of the ocean, produces a report which may be heard at a considerable distance. In progression, the action of this organ is precisely the reverse of that of the tail of the lobster, for whilst the latter animal swims backward by striking the water with its tail from behind forwards, the cachalot and other cetaceans swim forward by striking with their flukes in the contrary direction, the fin being brought beneath the body by an oblique and unresisting movement; while the act of springing it back and straightening the tail propels the animal ahead with an undulating or leaping gait. When employed offensively the tail is curved in a direction contrary to that of the object aimed at, and the blow is inflicted by the force of the recoil. The lower jaw appears diminutive, slender, and not unlike the lower mandible of a bird. When the mouth is closed it is received within the soft parts pendent from the border of the upper jaw, and is nearly

concealed by them. True and serviceable teeth are situated only in the lower jaw, and are received into corresponding sockets in the upper jaw. In aged males they are of great solidity and size, attaining a weight of from two to four pounds each; their entire structure is ivory. This powerful armament shows us at once that the food of the cachalot must be very different from that of the whalebone cetaceans; it generally consists of cuttle-



Cuttle-fish (Sepia).

fish, many kinds of which are ejected from its stomach when it is attacked by the boats, as well as after death. Owing to the great projection of the snout beyond the lower jaw, it may be requisite for this whale to turn on its side or back to seize its more bulky prey; a supposition strengthened by the fact that, when the animal attacks a boat with its mouth, it invariably assumes a reversed posture, carrying the lower jaw above the object it is attempting to bite. As long as it continues on the surface of the sea, the cachalot casts from its nostril a constant succession of spouts, at intervals of ten or fifteen seconds. As in all whales, the jets are not, as frequently imagined, water-columns, but a thick white mist ejected by one continual effort to the height of six or eight feet, and rushing forth with a sound resembling a moderate surf upon a smooth beach. The peculiar fat or sperm which renders the cachalot so valuable, is chiefly situated in the head. *Junk* is the name given by the fishermen to a solid mass of soft, yellow, and oily fat, weighing between two and three tons, based on the upper jaw, and forming the front and lower part of the snout; while the cavity called *case* is situated beneath and to the right of the spouting canal, and corresponds to nearly the entire length of that tube. It is filled with a very delicate web of cellular tissue, containing in

large cells a limpid and oily fluid, which is liberated by the slightest force. The quantity, chiefly spermaceti, contained in this singular receptacle, is often very considerable, nearly 500 gallons having been obtained from the case of one whale. So vast an accumulation of fat has obviously been intended to insure a correct position in swimming, to facilitate the elevation of the spiracle above the surface of the sea, and to counteract the weight of the bony and other ponderous textures of the head; objects which in the Greenland whale are sufficiently attained by a similar accumulation of fat in the lips and tongue, and by the more elevated situation of the spout-hole.

While the large whalebone whales generally roam about in solitary couples, the cachalot forms large societies. *Schools*, consisting of from twenty to fifty individuals, are composed of females attended by their young, and associated with at least one adult male of the largest size, who generally takes a defensive position in the rear when the school is flying from danger.

Pods are smaller congregations of young or half-grown males, which have been driven from the maternal schools. Two or more schools occasionally coalesce to a "*body of whales*," so that Bennett* sometimes saw the ocean for several miles around the ship swarming with sperm leviathans, and strewn with a constant succession of spouts. These large assemblies sometimes proceed at a rapid pace in one determinate direction, and are then soon lost sight of; at other times they bask and sleep upon the surface, spouting leisurely, and exhibiting every indication of being *at home*, or on their feeding ground. Like most gregarious animals, the cachalots are naturally timid. A shoal of dolphins leaping in their vicinity is sufficient to put a whole school to flight: yet occasionally fighting individuals are met with; particularly among those morose solitary animals, that most likely from their intolerable character have been turned out of the society of their kind. The central deserts of ocean, or the neighbourhood of the steepest coasts, are the chief resort of the cachalot; and so great is the difference of his *habitat* from that of the smooth-backed whales, that during the whole time Bennett was cruising in quest of cachalots, he in no single instance saw an example of the true whale. The cachalot

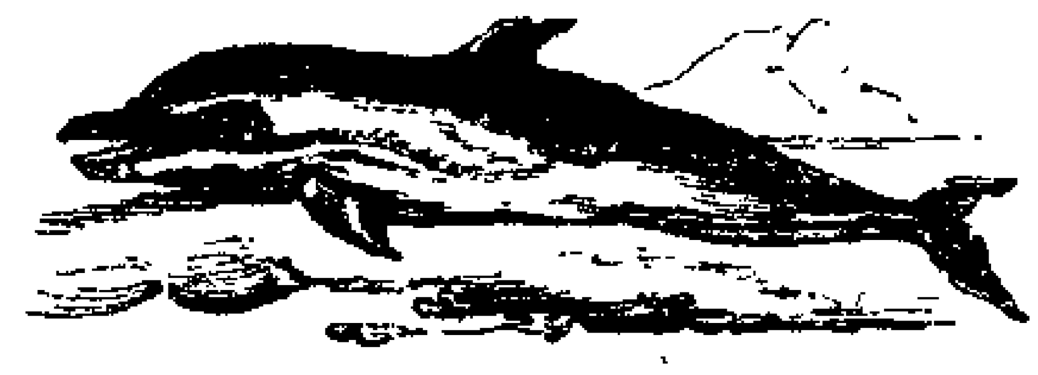
* Narrative of a Whaling Voyage round the Globe.

is more especially found on the *line-currents*, which extend from the equator to about the seventh degree of north and south latitudes, yet it has been noticed in the Mediterranean, and one individual, a stray sheep indeed, has even been captured in the Thames.

The Narwal, or Unicorn-fish, attains a length of from twenty to twenty-five feet. He is of a grey-white colour, punctured with many white spots, and as his head is not disproportionate to the length of his body, may rank among the handsomest cetaceans. He distinguishes himself, as is well known, from all other members of the family by the long twisted tooth or horn projecting horizontally from the upper jaw. This mighty weapon, the true use of which has not yet been fully ascertained, was formerly sold at a very high price, as proceeding from the fabulous unicorn; at present, it is only paid according to the worth of its excellent ivory, which is harder, heavier, and less liable to turn yellow than that of the elephant. The whalers are therefore highly delighted when they can pick up a chance narwal, but this only succeeds in narrow bays; for the unicorn-fish is an excellent swimmer, and extremely watchful. In spite of his menacing appearance, he is a harmless sociable creature, fond of gambolling and crossing swords playfully with his compeers. It is remarkable that the opening of the mouth of so huge an animal is scarcely large enough to admit the hand of a man. Scoresby found in the stomach of a narwal remains of cuttle fishes, which seem to form his chief aliment, besides pieces of skates and plaice. The narwal is frequent about Davis' Straits and Disco Bay, but is nowhere found in the Pacific, having most likely not yet discovered the north-western passage. He rarely wanders into the temperate seas, yet one was caught, in 1800, near Boston in Lincolnshire, and two others, in 1736, on the German coast of the North Sea.

The Dolphin tribe is distinguished from the cachalot by a more proportionate head; from the narwal by the absence of the long horn; and generally possesses sharp teeth in both jaws, all of one form. The number of species is very great; Linnæus distinguished four sperm whales and three dolphins; now many naturalists acknowledge but one species of the former, while the dolphins have increased to more than thirty, and many are as yet unknown.

The most famous member of this numerous family is undoubtedly the classical Dolphin of the ancients (*Delphinus delphis*) which attains a length of from nine to ten feet, and is, according to Pliny, the swiftest of all animals, so as to merit the appellation of the "arrow of the sea." His lively troops often accompany for days the track of a ship, and agreeably interrupt the monotony of a long sea-voyage. As if in mockery of the most rapid sailer, they shoot past so as to vanish from the eye, and then return again with the same lightning-like velocity. Their spirits are so brisk that they frequently leap into the air, as if longing to expatiate in a lighter fluid. Hence, dolphins are the favourites of the mariner and the poet, who have vied in embellishing their history with the charms of fiction.



Delphinus Delphis.

Everybody knows the wonderful story of Arion, who having been forced by pirates to leap into the sea, proceeded merrily to his journey's end on the back of a dolphin:—

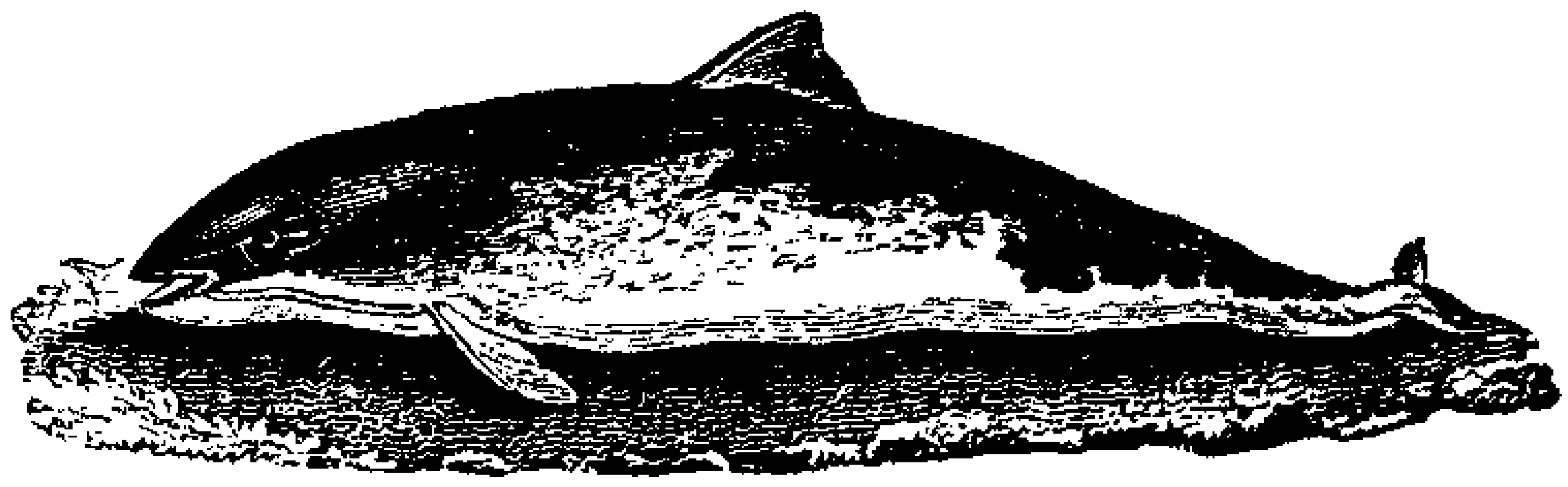
> "Secure he sits, and with harmonious strains
> Requites his bearer for his friendly pains.
> The gods approve, the dolphin heaven adorns,
> And with nine stars a constellation forms."

Pliny relates the no less astonishing tale of a boy at Baiæ, who by feeding it with bread, gained the affections of a dolphin, so that the thankful creature used to convey him every morning to school across the sea to Puteoli, and back again. When the boy died, the poor disconsolate dolphin returned every morning to the spot where he had been accustomed to meet his friend, and soon fell a victim to his grief. The same naturalist tells us also that the dolphins at Narbonne rendered themselves very useful to the fishermen by driving the fish into their nets, and were generously rewarded for their assistance with "bread soaked in wine." A king of Caria having chained a dolphin in the harbour, its afflicted associates appeared in great numbers, testifying their anxiety for its deliverance by such unequivocal signs of sorrow, that the king, touched with compassion, restored the prisoner to liberty.

Such, and similar fables, which were believed by the na-

turalists of antiquity, are laughed at even by the old women of our times. The dolphin is in no respects superior to the other cetaceans; his musical taste is as low as zero, and if, like the bonito and albacore, he follows a ship for days together, it is most surely not out of affection for man, but on account of the offal that is thrown overboard. But do not many human friendships repose on similar selfish motives?

The Porpoise, (*Delphinus Phocœna*) which only attains a



The Porpoise.

length of five or six feet, and seems to be the smallest of all cetaceans, is frequently confounded with the dolphin. It is at home in the whole Northern Atlantic, in the Mediterranean, and the Euxine. While the dolphin prefers the high sea, the porpoise loves tranquil bays and cliff-sheltered shores, and often swims up the rivers, so that individuals have been caught in the Elbe and Seine as high up as Dessau and Paris. The porpoise is a no less excellent swimmer than the dolphin, making at least fifteen miles an hour. His rapidity and sharp teeth render him a most dangerous enemy to all the lesser fry of the ocean, whose sole refuge lies in the shallowest waters. When he rises to the surface to draw breath, the back only appears, the head and tail are kept under water. At the entrance of harbours, where he is frequently seen gambolling, his undulatory or leaping movements, now rising with a grunt, now sinking to reappear again at some distance, afford an entertaining spectacle.

A much more formidable animal, the largest of the whole dolphin tribe, is the ravenous Grampus, (*Delphinus Orca,*) which measures no less than twenty-five feet in length, and twelve or thirteen in girth. The upper part of the body is black, the lower white: the dorsal fin rises in the shape of a cone, to the height of three feet or more.

All naturalists agree in describing the grampus as the most voracious of the dolphin family. Its ordinary food is the seal

and some species of flat-fish, but it also frequently gives chase to the porpoise, and perhaps the whale would consider the grampus as his most formidable enemy, were it not for the persecutions of man. Pliny gives us a fine description of the conflicts which arise between these monsters of the deep. At the time when the whale resorts to the bays to cast its young, it is attacked by the grampus, who either lacerates it with his dreadful jaws, or in rapid onset endeavours to strike in its ribs, as with a catapult. The terrified whale knows no other way to escape from these furious attacks, than by interposing a whole sea between him and his enemy. But the grampus, equally wary and active, cuts off his retreat, and drives the whale into narrower and narrower waters, forcing him to bruise himself on the sharp rocks, or to strand upon the shelving sands, nor ceases his efforts until he has gained a complete victory. During this fight the sea seems to rage against itself, for though no wind may be stirring the surface, waves, such as no storm creates, rise under the strokes of the infuriated combatants.

While the Emperor Claudius was visiting the harbour of Ostium, a grampus stranded in the shallow waters. The back appeared above the surface of the sea, and resembled a ship with its keel turned upwards. The Emperor caused nets to be stretched across the mouth of the harbour to prevent the animal's escape, and then attacked it in person with his prætorian guards. The soldiers surrounding the monster in boats, and hurling their inglorious spears, exhibited an amusing spectacle to the populace.

That man ventures to pursue the leviathans of the deep among the fogs and icebergs of the Arctic seas, and is generally successful in their capture, may surely be considered as one of the proudest triumphs of his courage and his skill.

The breast of the first navigator, says Horace, was cased with triple steel; but of what adamantine materials must that man's heart have been formed, whose steadfast hand hurled the first harpoon against the colossal whale?

History has not preserved his name; like the great warriors that lived before Agamemnon, he sank into an obscure grave for want of a Homer to celebrate his exploits. We only know that the Biscayans were the first *civilised* people that in the four-

teenth and fifteenth century fitted out ships for the whale fishery. At first the bold men of Bayonne and Santander contented themselves with pursuing their prey, (most likely rorquals) in the neighbouring seas, but as the persecuted whales diminished in frequency, they followed them farther to the north, until they came to the haunts of the real whale, whose greater abundance of fat rewarded their intrepidity with a richer spoil.

Their success naturally roused the emulation and avidity of other seafaring nations, and thus, towards the end of the sixteenth century, we see the English, and soon after the Dutch, enter the lists as their competitors. At first our countrymen were obliged to send to "Biskaie for men skilful in catching the whale, and ordering of the oil, and one cooper, skilful to set up the staved casks," (Hakluyt's *Voyages*, i. 414); but soon, by their skill, their industry and perseverance, together with the aid and encouragement granted by the legislature, they learnt to carry on the whale fishery on more advantageous terms than the original adventurers, whose efforts became less enterprising as their success was more precarious.

The first attempts of the English date as far back as the year 1594, when some ships were sent out to Cape Breton for morse and whale fishing. The fishing proved unsuccessful, but they found in an island 800 whale fins or whalebone, part of the cargo of a Biscayan ship wrecked there three years before, which they put on board and brought home. This was the first time this substance was imported into England.

Hull took the lead in the Greenland whale fishery in 1598, thirteen years after the first company for that purpose had been formed in Amsterdam, and as both maritime nations gave it every encouragement, not only on account of its profits, but also from considering it as one of the best nurseries for their seamen, it gradually grew to a very important branch of business. Some idea may be formed of the extent to which the Dutch engaged in the whale fishery during the last century, by stating that for a period of forty-six years preceding 1722, 5886 ships were employed in it, and captured 32,907 whales.

In the year 1788, 222 English vessels were employed in the northern fishery.

The earliest period at which we find the pursuit of the sperm

whale conducted upon a scientific plan is about 1690, when it was commenced by the American colonists. In 1775, ships were first sent out from ports of Great Britain, but for some years it was necessary to appoint an American commander and harpooner until competent officers could be reared. At the same early date the sperm fishery was chiefly prosecuted in the Atlantic, but Messrs. Enderby's ship "Emilia" having rounded Cape Horn in 1788, first carried the sperm whale fishery into the Pacific, where its success opened a wide and fruitful field for future exertions. As our whalers became better acquainted with the South Sea, many valuable resorts were discovered. In 1819 the "Syren" (British) first carried on the fishery in the western parts of that great ocean, and in the year 1848 the American whaler "Superior," Captain Roys, penetrated through Behring's Straits into the Icy Sea, and opened the fishery in those remote waters. The year after no less than 154 vessels followed upon his track, and the number has been increasing ever since. At present the Americans are the people which carries on the whale fishery with the greatest energy and good fortune. While of late years only thirty or forty British sail have been employed in the Pacific, our cousins "across the Atlantic" numbered in the year 1841 no less than 650 whalers, manned by 13,500 seamen. One of the causes of their success may be, that while the whale fishery in England is carried on by men of large capital, who are the sole proprietors of the ship, the American interest in one vessel is held by many men of small capital, and not unfrequently by the commander and officers. It must, however, not be forgotten that the Australian colonies, being more conveniently situated than the mother country, fit out many ships for the whale fishery, which is besides conducted in several permanent stations along the coasts of New Zealand, &c.

Whale charts have of late years been drawn, on which the best fishing grounds at different seasons are delineated. These maps are not only useful guides for the fishermen, but promise the future solution of the still undecided question of the migration of whales. While some naturalists are of opinion that the cetaceans, flying from the pursuit of man, abandon their old haunts for more sequestered regions, others, like M. Jacquinot (*Zoologie, Voyage de l'Astrolabe et de la Zèlée*) believe that if

the whaler is continually obliged to look out for more productive seas, it is not because the whale has migrated, but because he has been nearly extirpated in one place and left unmolested in another.

The Greenland whale fishery was for more than a hundred years confined to the seas between Spitzbergen and Greenland; the entrance and east shore of Davis' Straits not being frequented before the beginning of the last century. Since then the expeditions of Ross and Parry have made the whalers acquainted with a number of admirable stations on the farther side of Davis' Straits and in the higher latitudes of Baffin's Bay. The vessels destined for that quarter sail usually in March, though some delay their departure till the middle or even the end of April. They proceed first to the northern parts of the coast of Labrador, or to the mouth of Cumberland Strait, carrying on what is called the south-west fishery. After remaining there till about the beginning of May, they cross to the eastern shore of the strait and fish upwards along the coast, particularly in South-east Bay, North-east Bay, Kingston Bay, or Horn Sound.

About the month of July they usually cross Baffin's Bay to Lancaster Sound, which they sometimes enter, and occasionally even ascend Barrow's Strait twenty or thirty miles. In returning, they fish down the western shore, where their favourite stations are Pond's Bay, Agnes' Monument, Home Bay, and Cape Searle, and sometimes persevere till late in October. The casualties are generally very great, the middle of Baffin's Bay being filled with a compact and continuous barrier, through which, till a very advanced period of the season, it is impossible for the navigator to penetrate. Between this central body and that attached to the land, there intervenes a narrow and precarious passage, where many a vessel has been crushed or pressed out of the water and laid upon the ice. In 1819 ten ships were lost out of sixty-three, and in 1821 eleven out of seventy-nine. Fortunately the loss of lives is seldom to be deplored, as the weather is generally calm and the crew has time enough to escape in another vessel.

Whale fishing is not only a very dangerous and laborious pursuit, it is also extremely precarious and uncertain in its results. Sometimes a complete cargo of oil and whalebone is captured in a short time, but it also happens that after a long

cruise not a single fish is caught—a result equally unfortunate for the ship owner and the crew, who look to a share of the profits for their pay.

How much the whale fishery depends upon chance is shown by the following facts. In the year 1718 the Dutch Greenland fleet, consisting of 108 ships, captured 1291 fish, worth at least 650,000*l.*, while in the year 1710, 137 ships took no more than 62. Various meteorological circumstances—the prevalence of particular winds, the character of the summer or preceding winter—are probably the causes of the extraordinary failure and success of the fishery in different years. The Pacific is as fallacious as the Arctic seas. Thus Dumont d'Urville met in the Bay of Talcahuano with several whalers, one of whom had rapidly filled half his ship, while the others had cruised more than a year without having harpooned a single fish. In such cases the captains have the greatest trouble in preventing their men from deserting, who, being disappointed in their hopes, naturally enough look out for a better chance elsewhere.

The method of whale catching has been so often and so minutely described, that it is doubtless familiar to the reader. As soon as a whale is in sight, boats are got out with all speed, and row or sail as silently and quietly as possible towards the monster. One of the crew—the man of unflinching eye and nervous arm—stands upright, harpoon in hand, ready to hurl the murderous spear into the animal's side, as soon as the proper moment shall have come. When struck the whale dives down perpendicularly with fearful velocity, or goes off horizontally with lightning speed, at a short distance from the surface, dragging after him the line to which the barbed instrument of his agony is fixed. But soon the necessity of respiration forces him to rise again above the waters, when a second harpoon, followed by a third or fourth at every reappearance, plunges into his flank. Maddened with pain and terror, he lashes the crimsoned waters into foam, but all his efforts to cast off the darts that lacerate his flesh are vain, and his gaping wounds, though not "as deep as wells, nor as wide as church-doors," are still large enough to let out sufficient blood even to exhaust a whale. His movements become more and more languid and slow, his gasping and snorting more and more oppressed, a few convulsive heavings agitate the mighty mass,

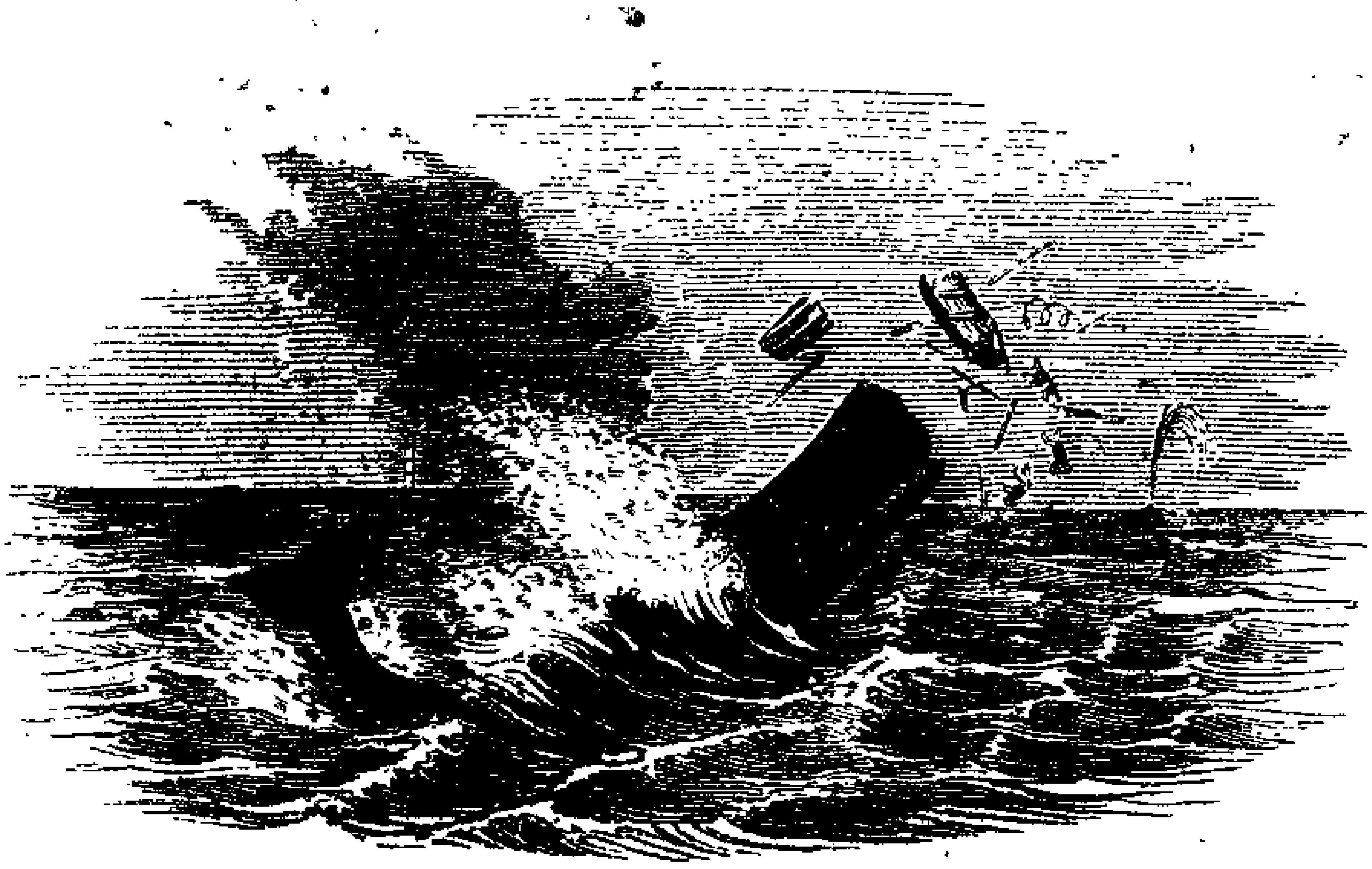
and then it floats inert and lifeless on the waters. As soon as death is certain—for to the last moment a convulsive blow of the mighty tail might dash the overhasty boat to pieces—the whale is lashed by chains to the vessel's side, stripped of his valuable fat, and then left to float, a worthless carcase, on the heaving ocean.

And now, man having taken his share, there begins a magnificent feast for birds and fishes. Crowds of fulmars, snow birds, or kittiwakes, flock together from all sides to enjoy the delicious repast; but their delight, so rare is perfect felicity on earth, is but too often disturbed by their terrible rival the blue gull (*Larus glaucus*), which, while it rivals them in rapacity, surpasses them all in strength, and forces them to disgorge the daintiest morsels. Meanwhile sharks, saw-fishes, and whatever else possesses sharp teeth and boldness enough to mix among such formidable company, are busy biting, hacking, scooping, and cutting below the water line, so that in a short time, notwithstanding its vast bulk, the carrion disappears.

The catching of the whale does not always end so fortunately as I have just described. Sometimes the line becomes entangled, and drags the boat into the abyss; or the tail of the animal, sweeping rapidly through the air, either descends upon the shallop, cutting it down to the water's edge, or encounters in its course some of the crew standing up (such as the headsman or harpooner), who are carried away and destroyed. Thus Mr. Young, chief mate of the "Tuscan," was seen flying through the air at a considerable height, and to the distance of nearly forty yards from the boat, ere he fell into the water, where he remained floating motionless on the surface for a few moments, and then sank and was seen no more.

Sometimes, particularly among the sperm-whales, desperate characters are found, that without waiting for the attack, rush furiously against the boats sent out against them, and seem to love fighting for its own sake. Bennett describes an encounter of this kind which he witnessed in the South Sea. The first effort of the whale was to rush against the boat with his head. Having been baffled by the crew steering clear, he next attempted to crush it with his jaws; failing again, through the unaccommodating position of his mouth, he remedied this defect with much sagacity, for approaching impetuously from a distance

of forty yards, he turned upon his back, raising his lower jaw to grasp the boat from above. A lance-wound, however, applied



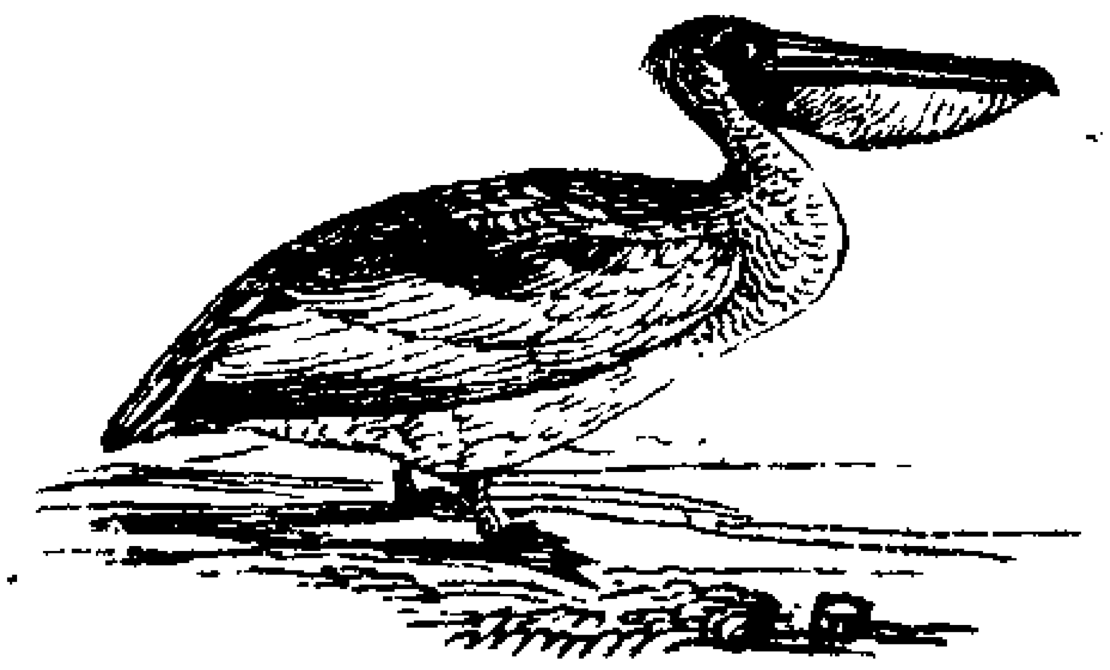
Sperm Whale.

in time, caused him to close his mouth; but continuing to advance, he struck the boat with such force that he nearly overturned it, and concluded by again turning on his back and thrusting his lower jaw through the planks. Fortunately the other boats came up to the rescue, and an addition of many tons of sperm to the ship's cargo made up for the damaged boat.

Although generally only the greater cetaceans are objects of pursuit at sea, yet man does not disdain the capture of the several dolphin-species when they approach his shores, and surrender themselves as it were into his hands. The intelligence that a shoal of ca'ing whales (*Delphinus melas*) has been seen approaching the coast, operates like an electric shock upon the inhabitants of the Feroe Islands. The whole village, old and young, is instantly in motion, and soon numerous boats push off from shore to surround the unsuspecting herd. Slowly and steadily they are driven into a bay, the phalanx of their enemies draws closer and closer together; terrified by stones and blows, they run ashore, and lie gasping as the flood recedes. Then begins the work of death, amid the loud rejoicings of the happy islanders. The visits of the ca'ing whale are extremely uncertain. From 1754 till 1776 scarce one was caught, but on the 16th of August of the last-named year more than 800 were

driven on the strand, and changed dearth into abundance. During the four summer months that Langbye sojourned on the islands in the year 1817, 623 of these large dolphins, mostly from eight to ten yards long, were caught, and served to pay one half of the imported corn. The division of spoil is made in presence of the "*Amtmann.*" Each fish is measured, and its size marked on its skin in Roman characters. The largest whale is given to the boat which first discovered the shoal; then others for the poor and clergyman are selected, and the remainder divided, according to stated rules, between the proprietor of the ground and the persons who drove them on shore. The flesh is either eaten fresh, or cut into slices and hung up to dry; whilst the blubber is partly converted into train oil, or salted in casks and barrels. The fat on the sides of the fish, when hung for a week or two, will keep for years, and is used instead of bacon by the natives.

The ca'ing whale, remarkable from following a leader and swimming in large herds, also strands from time to time on the coasts of Iceland and on the Shetland and Orkney Islands, where his appearance is hailed with universal pleasure.



Pelican

AUSTRALIAN SEA-BEARS.

AUSTRALIAN SEA-BEARS.

The group of Australian sea-bears is taken from the "Zoology of the voyage of H.M.S. Erebus and Terror." This animal, *Arctocephalus lobatus*, is among the largest of the Seal family. It is occasionally found congregating in vast numbers upon various portions of the coast of Australia.

CHAP. IX.

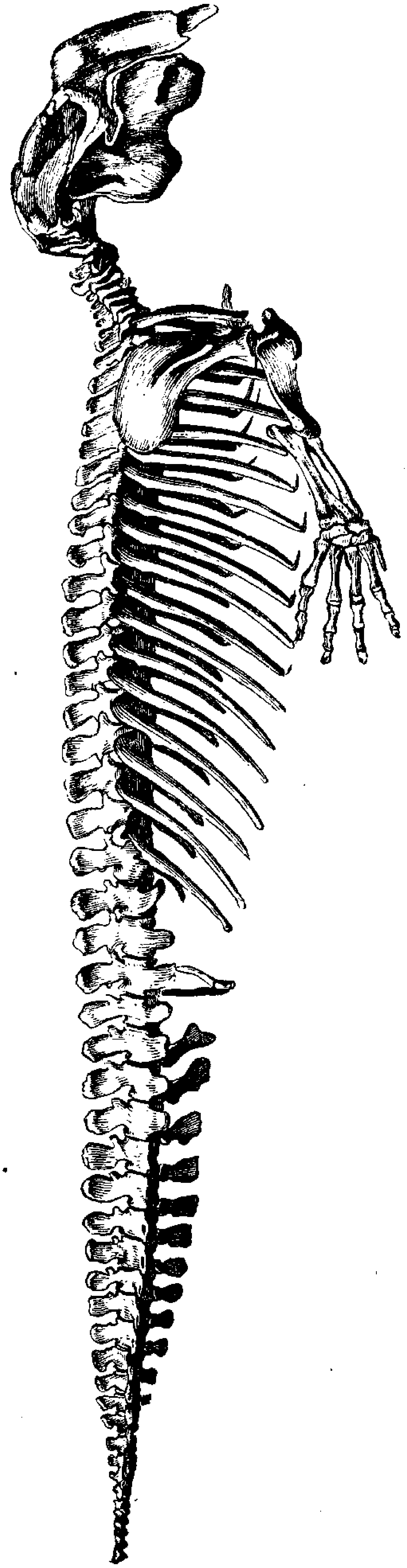
SEALS AND WALRUSES.

The Manatees and the Dugongs.—The Seals and the Esquimaux.—King Menelaus in a Seal's Skin.—Barbarous Persecutions of the Seals in Behring's Sea and the Pacific.—Adventures of a Sealer from Geneva.—The Sea Calf.—The Sea Bear. —His Parental Affection.—The Sea Lions.—The Sea Elephant.—The Arctic Walrus.—The Boats of the "Trent" fighting with a Herd of Walruses.—The White Bear.—Touching Example of its Love for its Young.—Chase of the Sea Otter.

The Manatees or Lamantins of the Atlantic Ocean, and the now nearly extinct Dugongs of the Indian seas, form the connecting link between the real whales and the seals and walruses. Like the whales, these animals have no hind feet, and a powerful tail, which is their chief instrument of locomotion; they are distinguishable, however, from them by less fin-like, more flexibly-jointed anterior extremities, on which they lean while cropping the sea-weeds on the shallow shores. When they raise themselves with the front part of their body out of the water, a lively fancy might easily be led to imagine that a human shape, though certainly none of the most beautiful, was surging from the deep. Hence they have been named sea-sirens, mermaids, and mermen, and have given rise to many extravagant fictions. Their intelligence is very obtuse, but their stolid calf-like countenance indicates great mildness of temper.

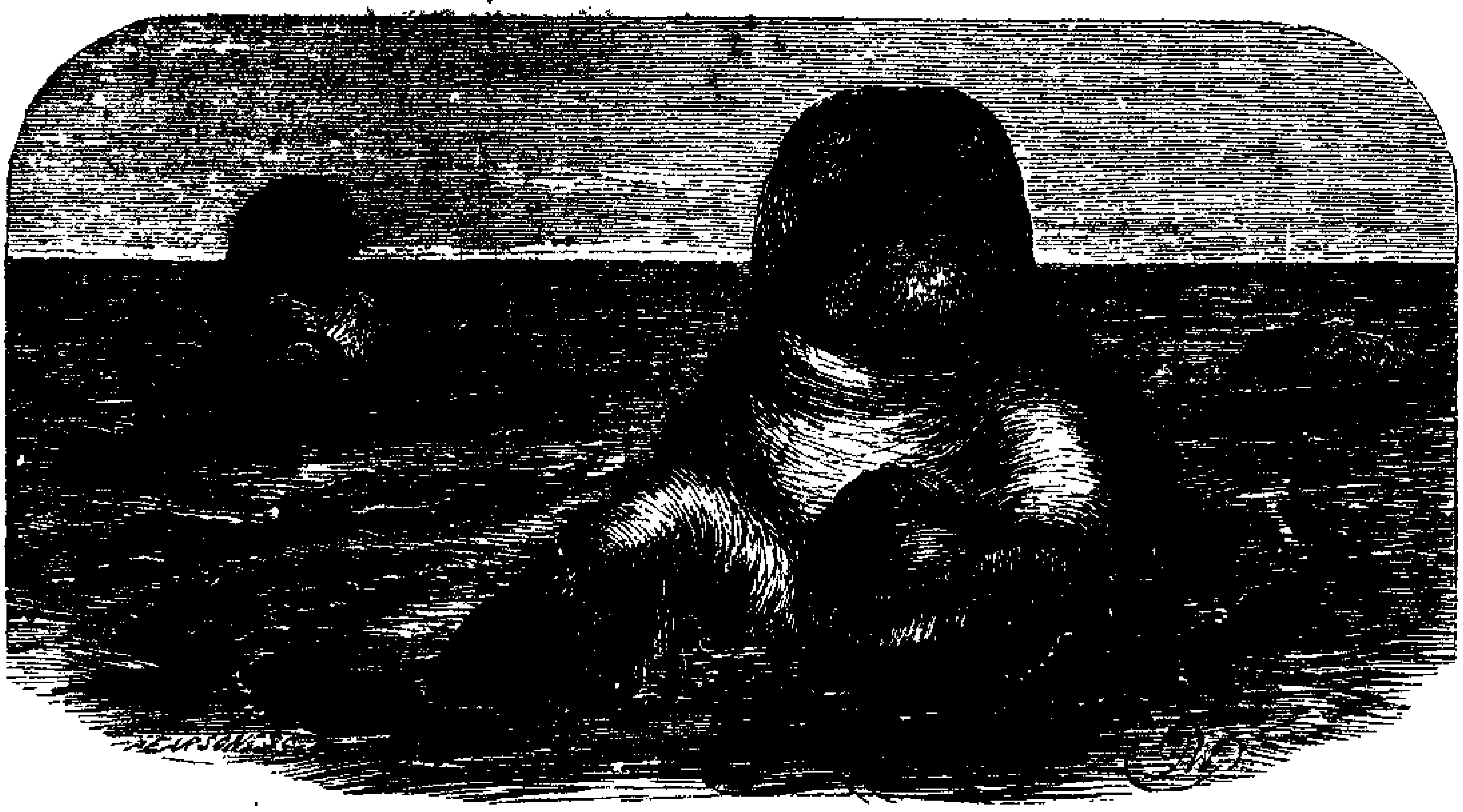
They live at peace with all other animals, and seem to be solely intent upon satisfying their voracious appetite. Like the hippopotamus, they swallow at once large masses of sea-plants or of juicy grasses growing beyond the water's edge on the borders of rivers.

The Manatees, or Sea-cows, as they are familiarly called, inhabit the coasts and streams of the Atlantic between 19° S. lat. and 25° N. lat., and attain a length of from eight to ten feet. Humboldt compares the flesh to ham, and Von


Skeleton of the Dugong.

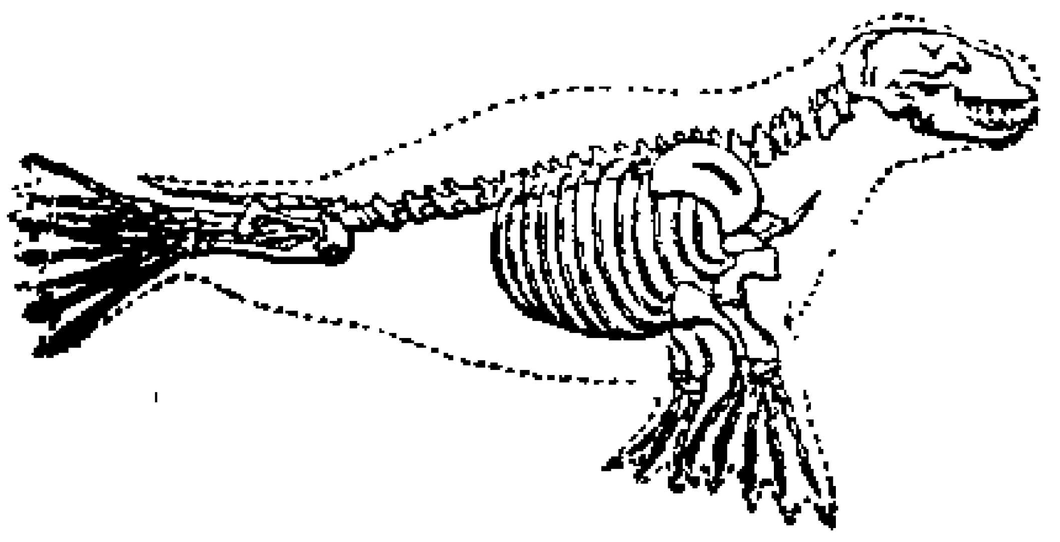
Martius says he never tasted better meat in the Brazils. The South American monks, who have their own ideas on the classification of animals, consider it as fish, and fare sumptuously upon it during Lent. Besides its flesh, one single animal gives as much as 4000 bottles of oil, which is used both in cookery and for lighting. The thick hide is cut into stripes, from which straps or whips are made, to flog the unfortunate negroes. Useful in many respects, defenceless and easy to kill, particularly during the time of the inundations, when it ascends the great rivers, the manatee or sea-cow has been nearly extirpated in many parts where it formerly abounded, a fate which it partakes with the East Indian dugong. These animals might easily be enclosed and tamed, in the lagoons and bays of the tropical streams; but it is to be feared that they will have vanished from the face of the earth before the industry of man endeavours to introduce them, as it were, among the domestic animals.

The Seal family forms a still nearer approach to the land quadrupeds, as here hind feet begin to make their appearance. The shortness of these extremities renders their movements upon land generally awkward and slow, but they make up for this deficiency by an uncommon activity in the water. Their body, taper-



Female Dugong of Ceylon. (From Sir J. Emerson Tennent's Work on Ceylon.)

ing fish-like from the shoulders to the tail, their abundance of fat, the lightness of which is so favourable to swimming, the position of their feet, admirably formed for rowing, paddling, and steering, their whole economy, in a word, is calculated for the sea. Although citizens of two worlds, their real element is evidently the water, from which their food is exclusively derived.



Skeleton of Seal.

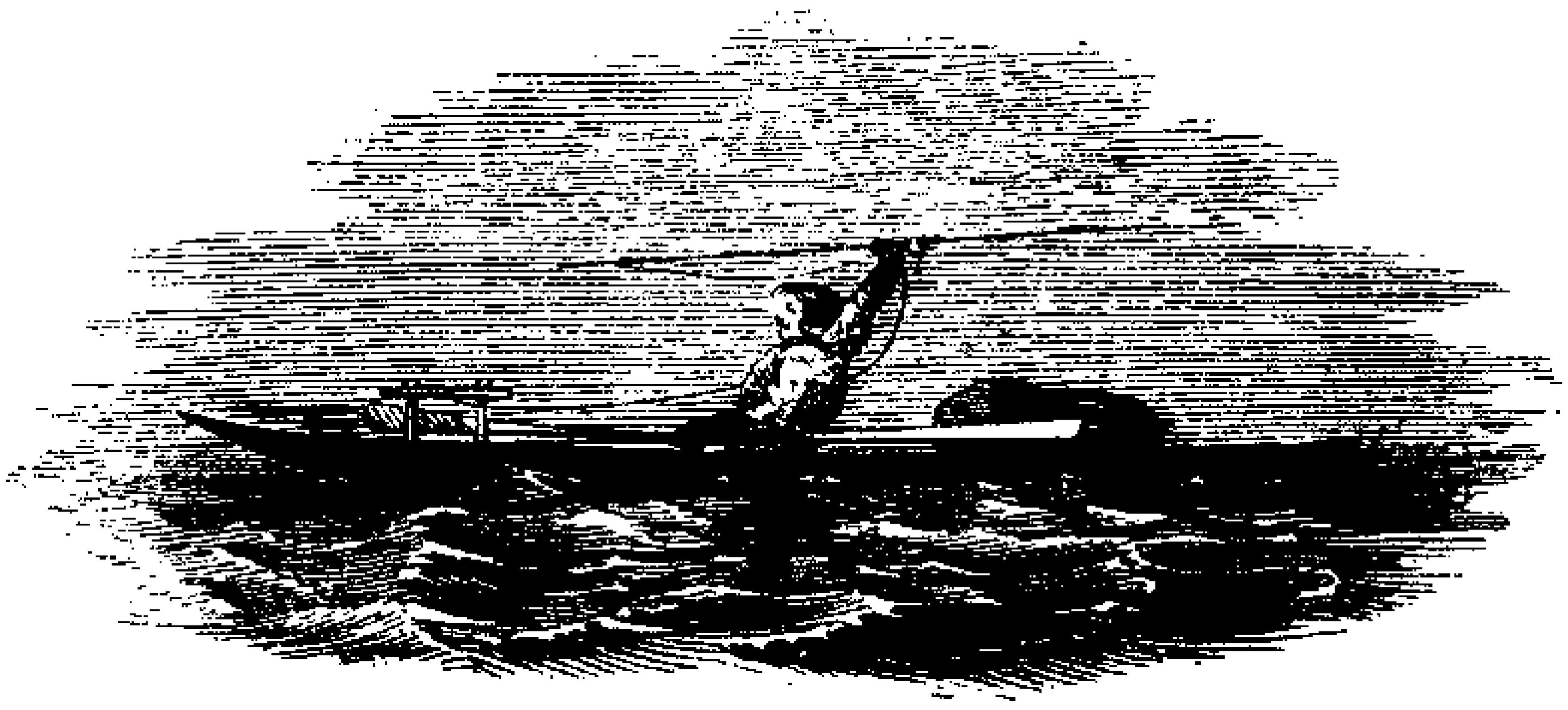
Seals are found in almost all seas, but they particularly abound on the coasts of the colder regions of the earth, and diminish in size and numbers as they approach the torrid zone. Small seals are found near Surinam, but the giants of the family, the huge sea-elephant, the sea-lion, the sea-bear, belong exclusively to those higher latitudes which the sun visits only with slanting rays, or where the winter forms a dreary and continuous night.

The Seal.

How wonderful to see the desolate coasts of the icy seas peopled by such herds of great warm-blooded mammalia! But there, where the dry land produces only the scantiest vegetation,

the bountiful sea teems with fishes, affording abundance to the hungry seals. The *Merlangus polaris* and the *Ophidium Parryii* in the northern hemisphere, as well as the *Nothothenia phocæ*, which Dr. Richardson discovered off Kerguelen's Land, seek in vain to escape from the pursuit of the seals in the hollows and crevices of the pack-ice; and these small fish, in turn, fare sumptuously upon the minute crustaceans and molluscs with which those cold waters abound. Thus animal life, but sparingly diffused over the barren land, luxuriates in the sea, where we find one species preying upon the other, until at last, at the bottom of the scale, we come to creatures so small as to be invisible to the naked eye.

The Greenland Esquimaux, whose ice-bound fatherland affords no food but berries, is also obliged to look to the sea for his subsistence; and the seal plays as important a part in his humble existence as the reindeer among the Laplanders, or the camel among the Bedouins of the desert. Its flesh and fat form his principal food; from its skin he makes his boat, his tent, his dress; from its sinews and bones, his thread and needles, his fishing line, and his bow-strings. Thus on the frozen confines of the Polar Sea, as in many other parts of the world, we find the existence of man almost entirely depending upon that of a single class of animals. But the Bedouin who tends the patient dromedary, or the Laplander who feeds on



Esquimaux in his Kayak.

the flesh and milk of the domesticated reindeer, enjoys an easy life when compared to the Esquimaux, who, to satisfy the cravings of his sharp appetite, is in all seasons obliged to brave all the perils of the Arctic Ocean. Sometimes he waits patiently for hours in the cold fog until a seal rises to the surface, or else he warily approaches a herd basking or sleeping on the ice blocks,

for the least noise awakens the watchful animals. Sometimes he has recourse to stratagem, covers himself with a seal skin, and, imitating the movements and gestures of the deceived phocæ, introduces himself into the midst of the unsuspecting troop.

We read in the *Odyssey* how the "dark-featured hero," Menelaus, deigned to conceal his royal limbs under a fresh seal-skin, in order to surprise Proteus, the infallible seer; and what sufferings his olfactory organs underwent from the

"Unsavoury stench of oil and brackish ooze,"

until the fair sea-nymph Eidothea, whom the gallant chief implored in his distress,

"With nectar'd drops the sickening sense restor'd."

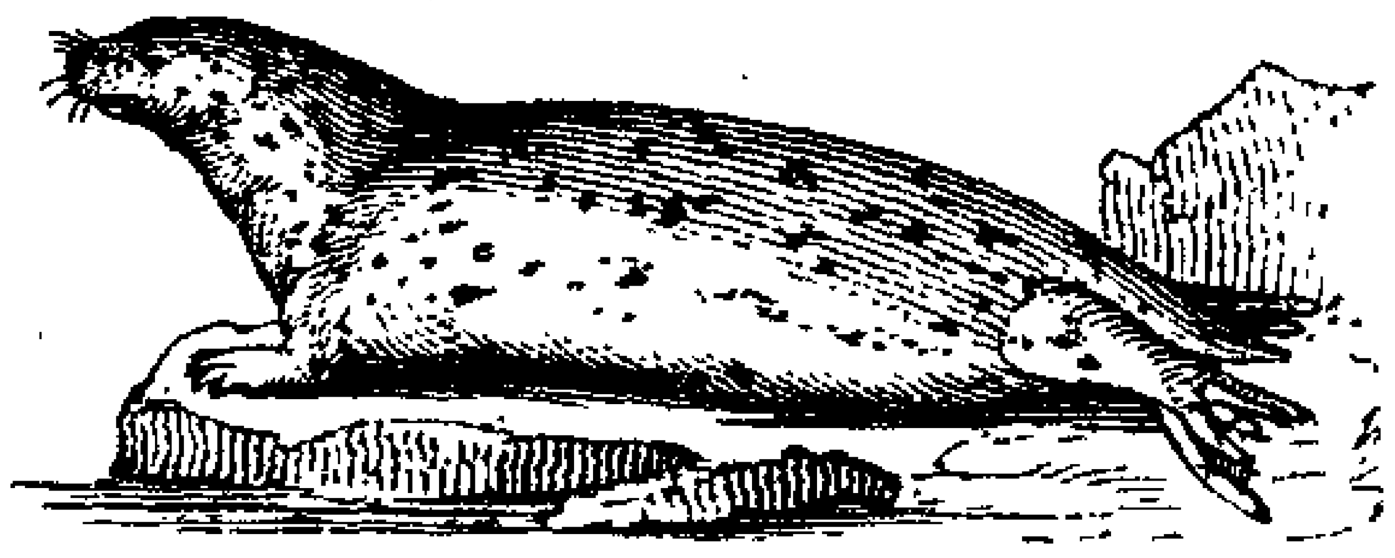
Fortunately for the Esquimaux, his nose is less sensitive than that of the son of Atreus, and without ambrosia, he willingly dons a disguise which affords his unsophisticated taste the pleasure of a theatrical entertainment, combined with the profit of a savoury prize. Physical strength, dexterity, caution, quickness of eye, and acuteness of hearing, are the indispensable qualities of the Esquimaux, and require to be exercised and developed from his tenderest years. The boy of fifteen must be as perfect a seal-catcher as his father, and be able to make all the instruments necessary for the chase. In these inhospitable regions, every one is obliged to rely upon himself alone; there, where all the powers of the body and mind are tasked to the utmost for the mere sustenance of life, weakness and want of dexterity must inevitably succumb.

Besides the savages of the north, the civilised nations also give chase to the seals, or rather wage a barbarous war of extermination against these helpless creatures. Thus, from the year 1786 to 1833, more than 3,000,000 sea-bears were killed on the Pribilow Islands, in Behring's Sea. At Unalaschka, the chief staple-place of the Russian Fur Company, 700,000 skins were cast into the water in the year 1803, on the same principle as that which induced the Dutch to burn their superfluous nutmegs, viz. "not to glut the market." As a well-merited punishment for this stupid slaughter, the products of the chase diminished rapidly from that time until within the last few years, when a better husbandry has again increased the number of the sea-bears.

Unfortunately, our own countrymen and the Americans have done no better in the southern seas. Thousands of sea lions used formerly to be killed on the South American coast, while at present the number of the animals is so much diminished as scarce to reward the sealer's trouble. Sir James Ross informs us that the sea elephant was formerly found in great numbers on Kerguelen's Land, and yearly attracted many vessels to those desert islands. But at present, after such incessant persecution, the animals have either migrated, or been almost totally extirpated. English and American captains often set some men ashore on the uninhabited coasts and islands of the southern seas, for the purpose of catching seals, boiling their oil, and stripping their skins. After a few months the ship generally returns to fetch the produce of their labours, or to bring a fresh supply of provisions to the seal catchers, who often remain several years in their solitary hunting grounds. But sometimes the poor wretches are abandoned by their associates, and then their despair may be imagined when week after week elapses without the expected sail appearing! Dumont d'Urville found one of these adventurers in the Straits of Magellan among a horde of Patagonians, who, though hospitably inclined, were themselves so poor as hardly to be able to keep body and soul together. He was a watchmaker from Geneva, who, having emigrated to New York, and finding himself disappointed, had listened to the fair promises of a skipper, who carried him out to Tierra del Fuego, and not finding the business answer, had left him to his fate. The French navigator took the poor man on board, and gave him a passage to Talcahuano in Chili.

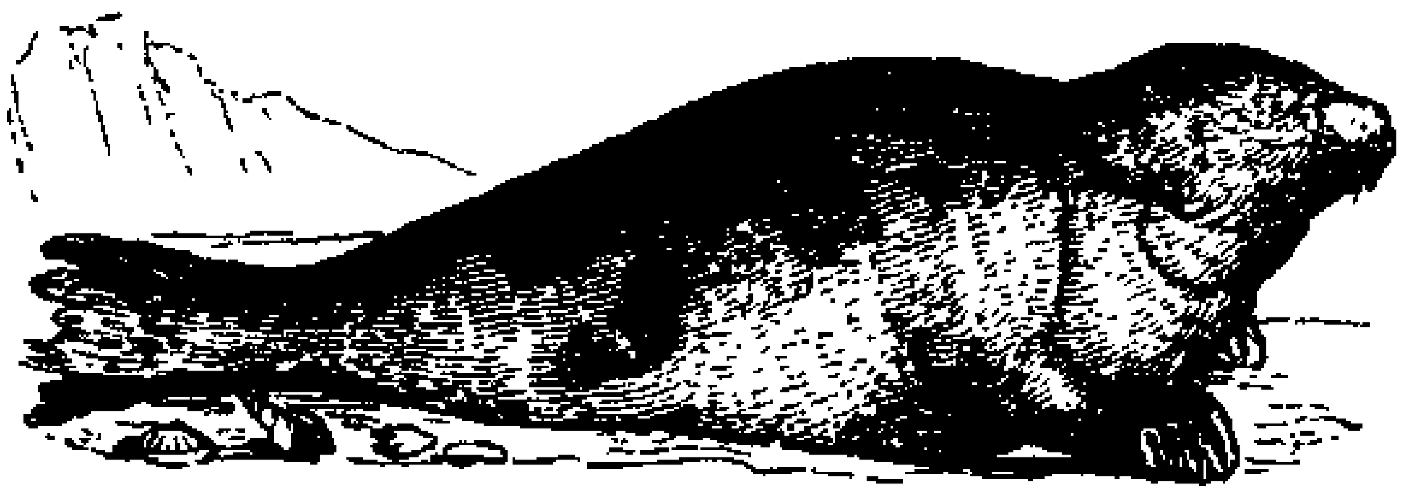
On the east coast of North America seal catching is still carried on with considerable success. Newfoundland intercepts many of the immense fields and islands of ice which in the spring move south from the Arctic Sea. The interior parts, with the openings or lakes interspersed, remain serene and unbroken, and form the transitory abodes of myriads of seals. In the month of March upwards of three hundred small vessels, fitted out for the seal fishery, are extricated from the icy harbours on the east coast of Newfoundland; the fields are now all in motion, and the vessels plunge directly into the edges of such as appear to have seals on them; the crews, armed with firelocks and heavy bludgeons, there *land*, and in the course

of a few weeks destroy nearly 300,000 of these animals. The Greenland winter, it would appear, is too severe for these luckless wanderers, and when it sets in, they accompany the field-ice, and remain on it until it is scattered and dissolved. Old and young being then deserted in the ocean, nature points out to them the course to their favourite icy haunts, and thither their herds hurry over the deep to pass an arctic summer. Winter returns, and with it commences again their annual migration from latitude to latitude. The Scotch ports, particularly Aberdeen, fit out ships for the spring seal-catching on the American coast, and are generally successful in their undertakings.



Greenland Seal.

According to the different numbers and forms of their canine teeth and grinders, and to the deficiency or presence of an *outward* ear, the seal tribe is divided into many families, genera, and species, among which I shall select a few of the most remarkable for further notice. The Common Seal or Sea-calf, (*Calocephalus vitulinus*), which owes the latter name to the unharmonious accents of its voice, attains a length of from five to six feet. It has a large round head, small short neck, and several strong bristles on each side of its mouth, large eyes, no external ears, and a forked tongue. It has six fore teeth in the upper jaw, four in the lower, a strong pointed canine tooth on each side in both jaws, and a goodly row of sharp and jagged grinders. Woe to the poor herring whose evil star leads him between these engines of destruction—he is irrevocably lost! Different species of common seals inhabit the Northern seas, from Greenland and Spitzbergen to the mouth of the Scheldt, and from the White Sea to the eastern coast of America. Others are found in the Antarctic seas. An excellent swimmer, the seal dives like a shot, and rises at fifty yards' distance, often remaining full a quarter of an hour under the water—three



Seal.

times longer than the most strong-breasted and expert pearl fisher. Yet he is seldom seen more than thirty miles from land, where he sleeps and reposes, choosing rocks surrounded by the sea or the less accessible cliffs, left dry by the ebb of the tide, so that, if disturbed by an enemy, he may be able to plunge immediately into the sea. In the summer he will come out of the water to bask or sleep in the sun on the top of large stones and ledges of rocks; and this affords our countrymen the opportunity of shooting him. If he chances to escape, he hastens towards his proper element, flinging dirt or stones behind him as he scrambles along, at the same time expressing his fears by piteous moans; but if he happens to be overtaken, he will make a vigorous defence with his feet and teeth till he is killed. His flesh, which is tender, juicy, and fat, was formerly, like that of the porpoise, served up at the tables of the great, as appears from the bill of fare of a magnificent feast that Archbishop Neville gave in the reign of Edward the Fourth. Seals commonly bring forth two young ones at a time, which they suckle for about a fortnight, and then carry them out to sea to instruct them in swimming. When taken young, they may be domesticated, and will follow their master like a dog, coming to him when called by name. According to Pliny, no animal enjoys a deeper sleep,—"nullum animal graviore somno premitur." This assertion is, however, contradicted by general observation, for it is well known that seals are extremely watchful, seldom sleeping longer than a minute without moving their heads to ascertain whether anything suspicious is going on.

Although without external ears, seals appear to hear well both above and under the water. Music or whistling will draw them to the surface and induce them to stretch their necks to the utmost extent—a curiosity which often proves a snare for their destruction. The most effectual way of shooting seals is by firing small shot into their eyes; for when killed with a bullet they generally sink and are lost. They are often seen in very large shoals on their passage from one situation to another. In such cases, all appear every now and then at the surface together for the sake of respiration, springing up so as to run their heads, necks, and often their whole bodies out of the water. They shuffle along, especially over the ice, with a surprising speed considering the shortness of their legs. They are

very tenacious of life, and able to survive even when shockingly mangled. According to Dr. Scoresby, the island of Jan Mayen affords excellent seal fishing in March and April. When on detached pieces of drift ice, they are captured by the use of boats, each boat making a descent upon a different herd. When the seals observe the boat, they endeavour to escape before it reaches the ice; the sailors, however, raise a long-continued shout, which frequently causes the amazed animals to delay their retreat until arrested by blows. When seals are abundant, the boat immediately pushes off after the slaughter is finished, and proceeds to another piece of ice for the increase of its harvest, leaving one man to flay off the skins and fat. But in situations where boats cannot navigate, the seal fishers have to pursue them over the ice, leaping from piece to piece until the capture is made; every man then flenses his own, and drags the skins and blubber to his boat or ship. Ships fitted out for seal fishing have occasionally procured cargoes of four or five thousand, yielding nearly a hundred tons of oil; but such enterprises are very hazardous, from the exposed nature of that dreary island, and the liability to heavy and sudden storms.

The Sea-Elephant (*Cystophora proboscidea*) deserves his name, not only from his immense size, attaining a length of twenty, twenty-five, or even thirty feet, but also from the singular structure of his elongated nostrils, which hang down when he is in a state of repose, but swell out to a foot-long proboscis when he is enraged. Then the beast has a most formidable appearance, which, along with its gaping jaws and dreadful roar, might strike terror into the boldest huntsman. But total helplessness and weakness conceal themselves behind this terrible mask, for a single blow upon the snout with a club suffices to fell the giant. Between 35° and 55° S. lat. is the home of the sea-elephant, where he frequents desert islands and uninhabited coasts. But even here, as I have already mentioned, he could not escape the rapacity of man, for his tough hide and the thick layer of blubber beneath were too tempting to remain unnoticed.

The Hooded Seal of the northern seas, (*Cystophora borealis,*) enjoys the same faculty of inflating a folding, skinny crest extending on each side from the snout to the eyes. But in spite of the menacing appearance of these wind-bags, the seal

fisher knocks him on the head, draws, without ceremony, his skin over his ears, and throws his blubber into the oil-kettle.

The *Otarias*, or seals furnished with an external ear, and whose longer and more developed feet allow them to move more freely on land, rank in point of organisation at the head of the whole tribe. The most important and valuable of all is the Sea-Bear (*Arctocephalus ursinus*), of which there are probably two species; the one inhabiting the Antarctic seas, while the other roams about the coasts and islands of the Northern Pacific, and selects St. Paul, one of the Pribilow group in Behring's Sea, as its favourite summer haunt. The fine-haired, black, curly skin of the younger animals, of from four months to one year old, is particularly esteemed, so as to be classed among the finer furs which find a ready sale in the Chinese market, and serve to decorate the persons of the higher rank of mandarins. The chase, which on the latter island was formerly a promiscuous massacre, is now reduced to the slaughter of a limited number of victims. It begins in the latter part of September, on a cold foggy day when the wind blows from the side where the animals are assembled on the rocky shore. The boldest huntsmen, accustomed to clamber over stones and cliffs, open the way; then follow their less experienced comrades, and the chief personage of the band comes last, to be the better able to direct and survey the movements of his men, who are all armed with clubs. The main object is to cut off the herd as quickly as possible from the sea. All the grown-up males and females are spared, but the younger animals are all driven landwards, sometimes to the distance of a couple of miles, and then partly clubbed to death. Those which are only four months old are doomed without exception; while of the others only a certain number of the males are killed, and the females allowed to return again to the coast, when they soon betake themselves to the water. For several days after the massacre, the bereaved mothers swim about the island, seeking and loudly wailing for their young.

From the 5th of October, St. Paul is gradually deserted by the sea bears, who then migrate to the south, and reappear towards the end of April,—the males arriving first. Each seeks the same spot on the shore which he occupied during the preceding year, and lies down among the large stone blocks with which the flat beach is covered. About the middle of May the far more

numerous females begin to make their appearance, and Otarian life takes full possession of the strand. The full-grown sea-bear is from eight to nine feet long, measures five in girth, and acquires a weight of from eight to nine hundred pounds. He owes his name to his shaggy blackish fur, and not to his disposition, which is far from being cruel or savage. He indulges in polygamy like a Turk or a Mormon, and has often as many as fifty wives. The young are generally lively, fond of play and fight. When one of them has thrown another down, the father approaches with a growl, caresses the victor, tries to overturn him, and shows increasing fondness the better he defends himself. Lazy and listless youngsters are objects of his dislike, and these hang generally about their mother. The male is very much attached to his wives, but treats them with all the severity of an oriental despot. When a mother neglects to carry away her young, and allows it to be taken, she is made to feel his anger. He seizes her with his teeth, and strikes her several times, not over gently, against a cliff. As soon as she recovers from the stunning effects of these blows, she approaches her lord in the most humble attitudes, crawls to his feet, caresses him, and even sheds tears, as Steller, the companion of Behring's second voyage, informs us. Meanwhile the male crawls about to and fro, gnashes his teeth, rolls his eyes, and throws his head from side to side. But when he sees that his young is irrevocably lost, he then, like the mother, begins to cry so bitterly, that the tears trickle down upon his breast. In his old age the ursine seal is abandoned by his wives, and spends the remainder of his life in solitude, fasting, and sleeping; an indolence from which he can only be roused by the intrusion of another animal, when a tremendous battle is the consequence. Though extremely irascible, the sea-bears are lovers of fair play, so that when two are fighting, the others form a ring, and remain spectators until the contest is decided. Then, however, they take the part of the weaker, which so enrages the victor that he immediately attacks the peace-makers. These in turn fall out, the dreadful roaring attracts new witnesses, and the whole ends, like an Irish wedding, with a general fight.

Ursine seals are also found in the southern hemisphere, on desert coasts analogous to their residences in the north. Common seals and sea-otters stand in great awe of these animals,

and shun their haunts. They again are in equal fear of the Leonine seals, and do not care to begin a quarrel in their presence, dreading the intervention of such formidable arbitrators, who likewise possess the first place on the shore.

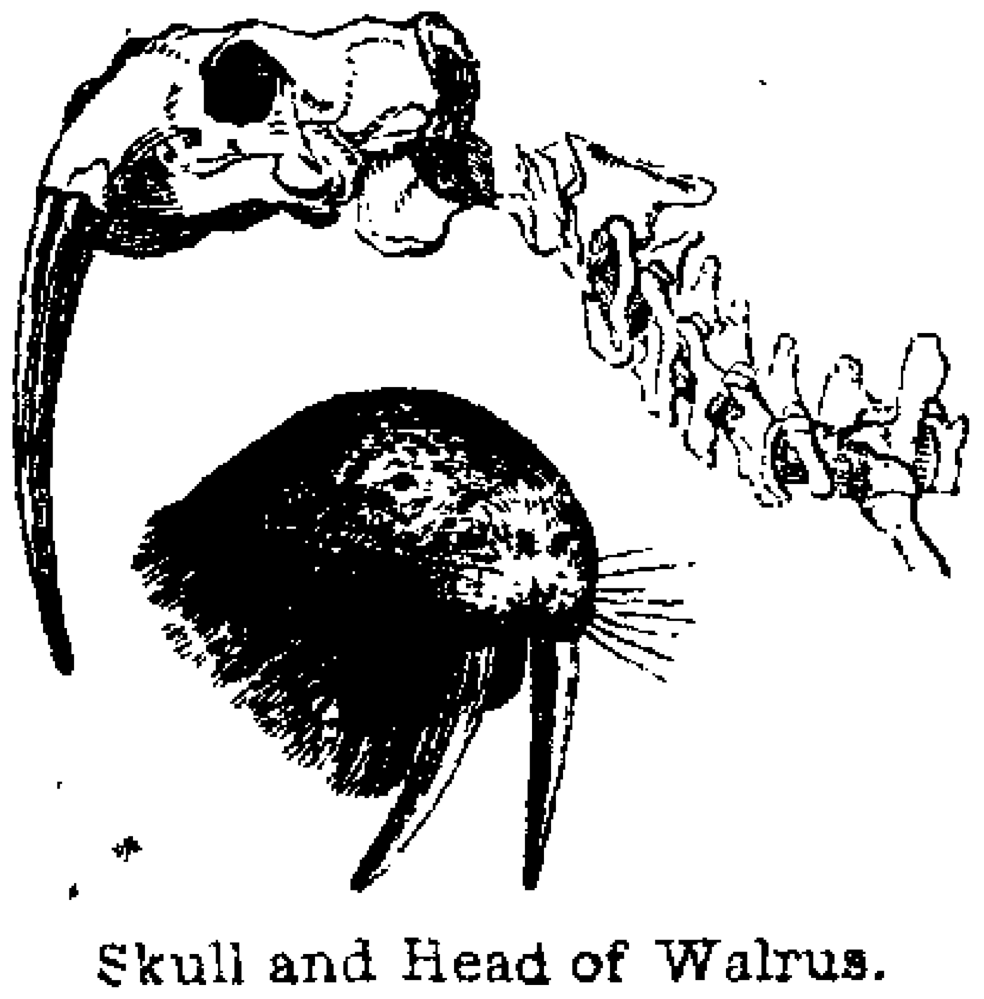
Steller's Sea-Lion, (*Otaria Stelleri,*) is about as large again as the sea-bear, but its tawny hide, covered with short bristles, is without value in the fur trade. To the Aleut, however, the animal is of great use, for he covers his boat with its skin, makes his water-tight *kamleika* with its intestines, the soles of his shoes with the webs of its feet, ornaments his cap with its long beard hair, and feasts upon its flesh. On all the coasts and islands of the Pacific this sea-lion is found, from 61° N. lat. to unknown southern limits, but nowhere in such numbers as on the Pribilow Island, St. George, where its countless herds afford a wonderful spectacle. The shapeless gigantic fat and flesh-masses, awkward and unwieldy on land, cover, as far as the eye can reach, a broad, rocky, naked strand-belt, blackened with oil. The sea-birds occupy the empty places between the herds of the sea-lions, and fly fearlessly before the gaping jaws of the huge monsters, without caring about their hideous bellowing. In countless numbers they build their nests in the caves of the surf-beaten cliffs, and among the large boulders on the shore, whose tops are whitened with their dung. A thick fog generally spreads over the desolate scene, and the hollow roaring of the breakers unites, with the screaming of the birds and the bellowing of the sea-lions, to form a wild and melancholy concert.

Steller's sea-lion is furnished only with an erect and curly hair-tuft at his neck, while a complete mane flows round the breast of the sea-lion of the southern hemisphere, (*Otaria jubata*). The remainder of the body is covered with short smooth hairs, or bristles. The sea-lioness has no mane, and is darker than the male. The fore-fins have the appearance of large pieces of black tough leather, showing, instead of nails, slight horny elevations; the hind-fins, which are likewise black, have a closer resemblance to feet, and the five toes are furnished with small nails. A formidable-looking beast, eleven feet long! and well may the naturalist start, when, walking through the high tussack grass of the Falkland Islands, he suddenly stumbles over a huge sea-lion, stretched along the ground, and blocking up his path.

The Arctic Walrus forms the nearest approach to the seals in the scale of creation, and is likewise better adapted for a marine life than for existence on dry land. But he is completely without fore-teeth, and his grinders have a broad furrowed crown, like those of the herbivorous animals. This difference of dentition points to a different food, and while the phocæ are such voracious fish-eaters that Sir James Ross found no less than twenty-eight pounds of undigested fish in the stomach of a southern seal, the walrus principally lives on sea-weeds and molluscs. The Arctic walrus or sea-horse (*Trichechus rosmarus*) is one of the largest mammals known, as he sometimes grows to the length of eighteen feet, and so thick as to measure twelve feet about the middle of the body. His form is very clumsy, having a small head, a strong elongated neck, a thick body, and short legs, the hind feet uniting to a broad fin. With such a form, no one can wonder at the clumsiness of its movements on land. Admiral Beechey describes the gallop of a sea-horse as probably the most awkward motion exhibited by the animal tribe, for, like a large caterpillar, the unwieldly creature alternately lowers and raises its head, in order to facilitate the bringing up of the hinder parts of the body;—no easy task, when we consider the immense weight of the animal, and the great disproportion between the length of its body and its legs.

Walrus, or Morse.

The upper lip, which is very thick, and indented or cleft into two large rounded lobes, furnished with thick yellow bristles, contributes also but little to its external beauty. From under this formidable-looking inflation protrude two large and long tusks, growing, like those of the elephant, from the upper jaw, but bent downwards, not outward and upwards, as is the case with the latter. Their uses are also very different, for while the elephant employs his tusks in digging up roots, the walrus raises by their assistance



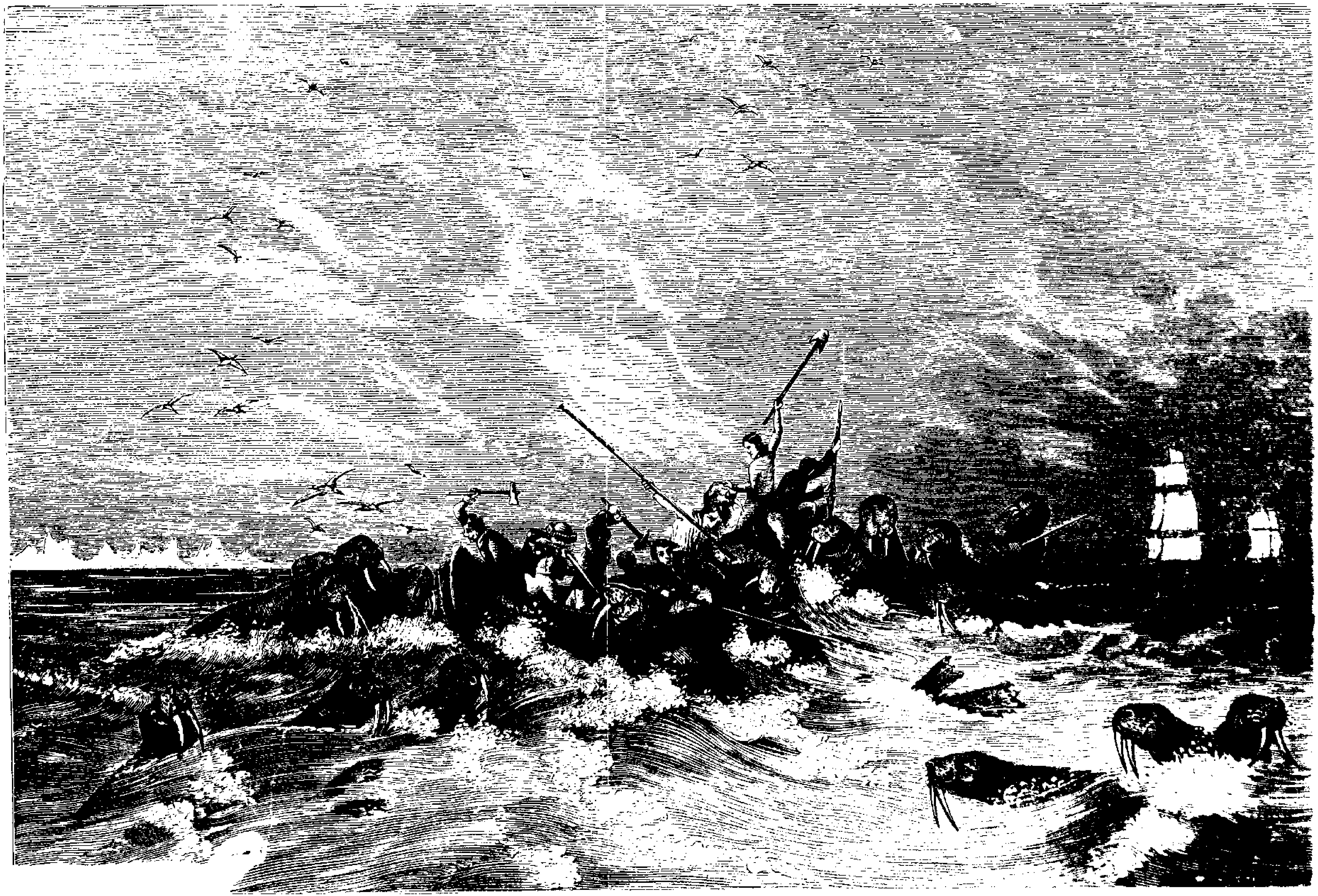
Skull and Head of Walrus.

his unwieldy body upon the ice-blocks and precipitous shores, where he loves to bask in the sun. Both animals use them, moreover, as formidable weapons, the former against the bounding tiger, the latter against the hungry ice-bear or the voracious shark.

In fine weather the walruses, like the seals, gather on the ice, where they may be seen in herds consisting occasionally of upwards of 100 animals each. In these situations they appear greatly to enjoy themselves, rolling and sporting about, and frequently making the air resound with their bellowing, which bears some resemblance to that of a bull. These diversions generally end in sleep, during which these wary animals appear always to take the precaution of having a sentinel to warn them of any danger to which they may be liable. So universal seems the observance of this precaution amongst their species, that Beechey, who had many opportunities of observing them in Spitzbergen, scarcely ever saw a herd, however small, in which he did not notice one of the party on the watch, stretching his long neck in the air every half-minute, to the utmost extent of its muscles, to survey the ground about him. In the event of any alarming appearances, the sentinel begins by seeking his own safety; and as these animals always lie huddled upon one another, the motion of one is immediately communicated to the whole group, which is instantly in motion towards the water. When the herd is large, and an alarm is given, the consequences are most ludicrous. From the unwieldy nature of the animals, the state of fear into which they are thrown, and their being so closely packed together, at first they tumble over one another, get angry, and in their endeavour to regain their feet flounder about in each other's way, till having at last scrambled to the edge of the ice, they tumble into the water, head first, if possible, but otherwise, in any position in which chance may have placed them, occasioning one of the most laughable scenes it is possible to conceive.

Though the first movement of the walruses at the approach of danger is to seek the water, yet here, enraged by an unprovoked attack, they often become most formidable assailants; of which Beechey recounts a remarkable instance.

One evening, while the Dorothea and Trent were at anchor in Magdalena Bay, Spitzbergen, several herds of these animals



THE BOATS OF H.M.S. TRENT ATTACKED BY WALRUSES.

THE BOATS OF H.M.S. TRENT ATTACKED BY WALRUSES.

THIS plate is taken from an incident narrated in the account of the voyage of H.M. ships Dorothea and Trent. The boat belonging to the Trent was attacked by a shoal of walruses, which were near swamping it; and were not driven off till a gigantic walrus, which appeared to be the captain of the shoal, was destroyed by a shot fired into its throat as represented in the engraving, the original of which, as published in the account of the voyage, was taken from a sketch by an officer present in the singular conflict.

had crawled upon the ice, to enjoy the fine weather and rest themselves. The boats, properly equipped, and manned with some of the officers and seamen, pushed off in pursuit of them. The first herd which was selected disappointed the sportsmen, but another was so intent upon its gambols, that the sentinel absolutely forgot his duty, and several of the crew managed to effect a landing upon the ice without any alarm being given to the animals; as soon, however, as the first musket was fired, the affrighted group made such a desperate rush towards the edge of the ice that they nearly overturned the whole of the assailing party, purposely stationed there to intercept them. The seamen, finding this charge more formidable than they expected, were obliged to separate to allow their opponents to pass through their ranks; and being thus in their turn taken by surprise, they suffered them, almost unmolested, to perform their somersaults towards the sea. What with their uncertain movements, the extreme toughness of their skin, and the respectful distance at which the men were obliged to keep, to avoid the lashing of the head and tusks of the animals, it was indeed no easy task to inflict any serious injury upon them. One, however, was desperately wounded in the head with a ball, and the mate of the brig, being determined if possible to secure his prey, resolutely struck his tomahawk into his skull; but the enraged animal, with a twist of its head, sent the weapon whirling in the air, and then lashing his neck, as though he would destroy with his immense tusks everything that came in his way, effected his escape to the water. The seamen followed and pushed off in their boats; but the walruses, finding themselves more at home now than on the ice, in their turn became the assailants. They rose in great numbers about the boats, snorting with rage, and rushing at the boats, and it was with the utmost difficulty they were prevented upsetting or staving them by placing their tusks upon the gunwales, or by striking at them with their heads. It was the opinion of the seamen that in this assault the walruses were led on by one animal in particular, a much larger and more formidable beast than any of the others, and they directed their efforts more particularly towards him; but he withstood all the blows of their tomahawks without flinching, and his tough hide resisted the entry of the whale lances, which were unfortunately not very sharp, and soon

bent double. The herd was so numerous, and their attacks so incessant, that there was not time to load a musket, which indeed was the only effectual mode of seriously injuring them. The purser fortunately had his gun loaded, and the whole now being nearly exhausted with chopping and striking at their assailants, he snatched it up, and thrusting the muzzle down the throat of the leader, fired into his bowels. The wound proved mortal and the animal fell back amongst his companions, who immediately desisted from the attack, assembled round him, and in a moment quitted the boat, swimming away as hard as they could with their leader, whom they actually bore up with their tusks, and assiduously preserved from sinking. Whether this singular and compassionate conduct, which in all probability was done to prevent suffocation, arose from the sagacity of the animals, it is difficult to say; but there is every probability of it, and the fact must form an interesting trait in the history of the habits of the species. After the discharge of the purser's gun, there remained of all the herd only one little assailant, which the seamen, out of compassion, were unwilling to molest. This young animal had been observed fighting by the side of the leader, and from the protection which was afforded it by its courageous patron, was imagined to be one of its young. This little animal had no tusks, but it swam violently against the boat, and struck her with its head, and indeed would have stove her, had it not been kept off by whale lances, some of which made deep incisions in its young sides. These, however, had not any immediate effect; the attack was continued, and the enraged little animal, though disfigured with wounds, even crawled upon the ice in pursuit of the seamen, who had *relanded* there, until one of them, out of compassion, put an end to its sufferings.

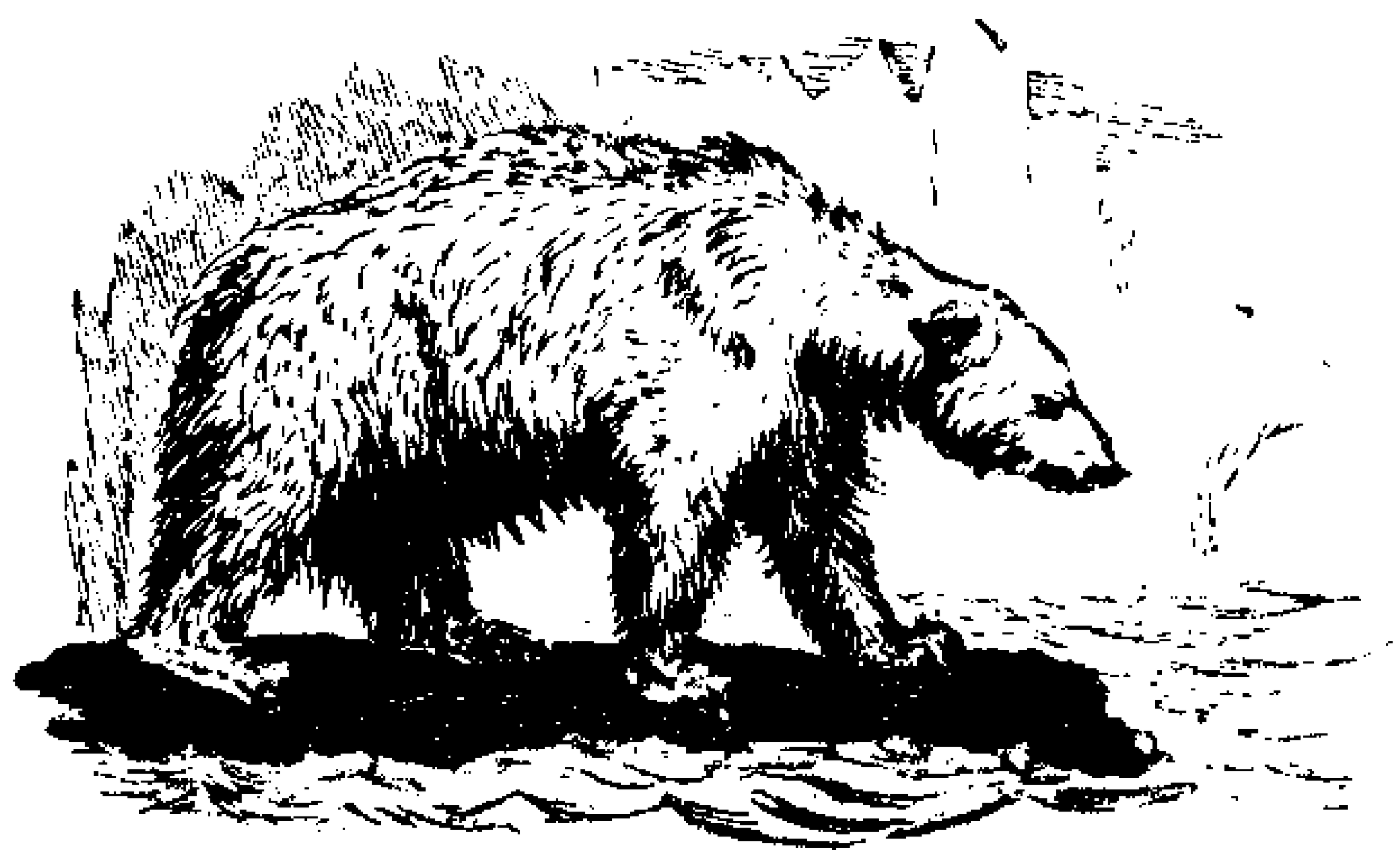
The valuable ivory of its tusks, which is more solid, finer grained, and whiter than that of the elephant, exposes the walrus to the attacks of man, no less than his thick hide, from which a strong elastic leather is made, and his abundance of flesh and blubber. The former are sought by civilised nations, while the latter forms the chief food of the northern Esquimaux and of the Tschutchi on the western shore of Behring's Straits.

Every year a troop of Aleuts land on the northern coast of the peninsula of Aliaska, where the young walruses assemble in great numbers during the summer, having most

likely been driven away by the older males from their more northern haunts. The walruses herd on the lowest edge of the coast which is within reach of the high spring-tides. When the Aleuts prepare to attack the animals, they take leave of each other as if they were going to face death, being no less afraid of the mighty tusks of the walruses than of the awkwardness of their own companions. Armed with lances and heavy axes, they stealthily approach the walruses, and having disposed their ranks, suddenly fall upon them with loud shouts, and endeavour to drive them from the sea, taking care that none of them escape into the water, as in this case the rest would irresistibly follow and precipitate the huntsmen along with them. As soon as the walruses have been driven far enough up the strand, the Aleuts attack them with their lances, endeavouring to strike at them in places where the hide is not so thick, and then pressing with all their might against the spear, to render the wound deep and deadly. The slaughtered animals fall one over the other and form large heaps, while the huntsmen, uttering furious shouts and intoxicated with carnage, wade through the bloody mire. They then cleave the jaws and take out the tusks, which are the chief objects of the slaughter of several thousands of walruses, since neither their flesh nor their fat is made use of in the colony. Sir George Simpson, in his "Overland Journey Round the World," relates that the bales of fur sent to Kjachta are covered with walrus hide; then it is made to protect the tea chests, which find their way to Moscow; and after all these wanderings, the far-travelled skin returns again to its native seas, when, cut into small pieces and stamped with a mark, it serves as a medium of exchange. The carcases of the wholesale slaughter are left on the shore to be washed away by the spring-tides, which soon erase every vestige of the bloody scene, and in the following year the inexhaustible north sends new victims to the coast.

Kane gives us a vivid description of a walrus hunt in Smith's Sound, most likely the most northern point of the earth inhabited by man. "After a while Myouk became convinced, from signs or sounds, that walruses were waiting for him in a small space of recently open water that was glazed over with a few days' growth of ice, and, moving gently on, soon heard the characteristic bellow of a bull,—the walrus, like some bipeds, being

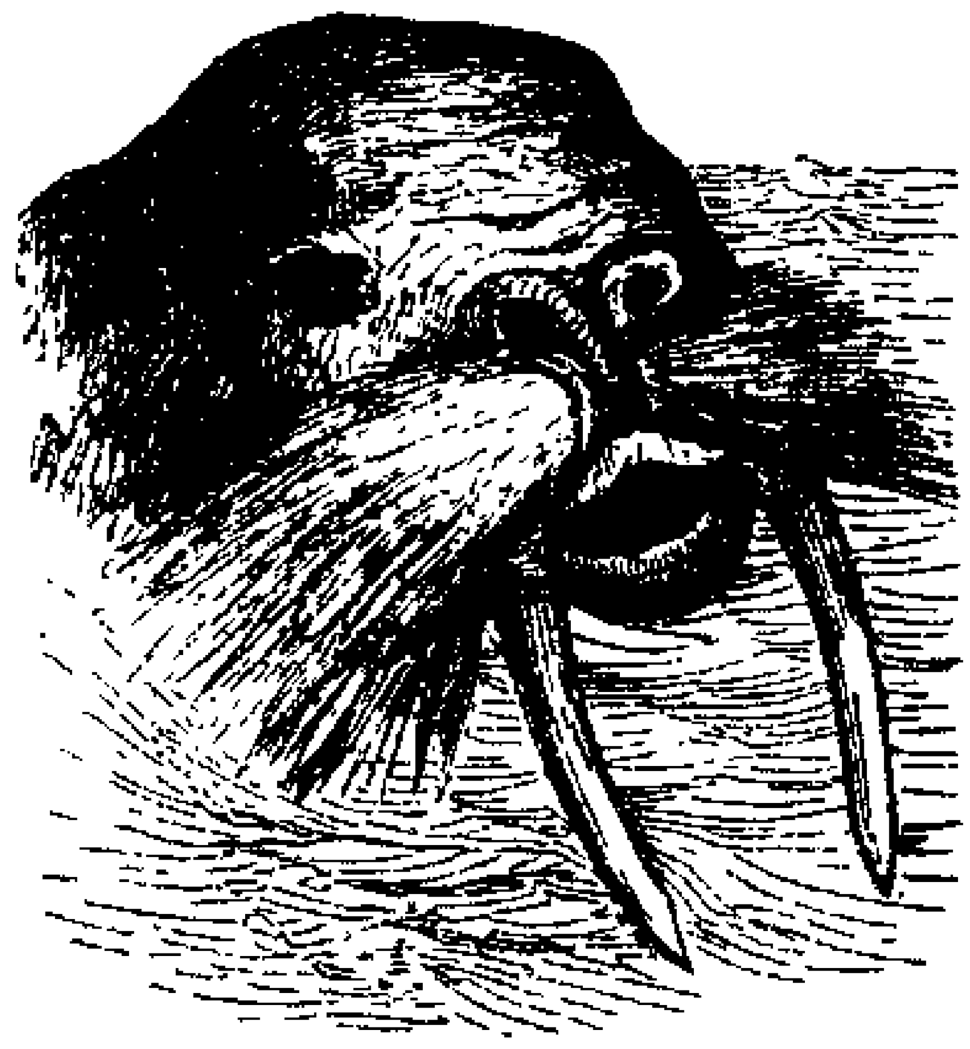
fond of his own music. The party now formed in single file, and moved on in serpentine approach to the recently frozen ice spots, which were surrounded by older and firmer ice. When within half a mile the line broke, and each man crawled towards a separate pool. In a few minutes the walruses were in sight, five in number, rising at intervals through the ice in a body with an explosive puff that might have been heard for miles. Two large grim-looking males made themselves conspicuous as leaders of the group. When the walrus is above the water, the hunter lies flat and motionless; as it begins to sink, he is alert and ready for a spring. The animal's head is hardly below the water line, when every man advances in rapid run, and again, as if by instinct, before the beast returns, all are motionless behind protecting knolls of ice. In this way the Esquimaux have reached a plate of thin ice, hardly strong enough to bear them, at the very brink of the pool. Myouk, till now phlegmatic, seems to waken with excitement. A coil of walrus hide lies by his side, and he grasps the harpoon, ready for action. Presently the water is in motion, and, puffing with pent-up respiration, the walrus rises before him. Myouk rises slowly, the right arm thrown back, the left flat at his side. The walrus looks about him, shaking water from his crest, Myouk throws up his left arm, and the animal, rising breast-high, fixes one look before he plunges. It has cost him all that curiosity can cost, for the harpoon lies buried under his left flipper." The wounded animal makes a desperate spring, and endeavours to lift itself upon the ice, which breaks under its weight. These fruitless endeavours give its physiognomy a still more vengeful expression; its bellowing degenerates into a roar, and crimson foam gathers round its mouth.


Polar Bear (*Ursus maritimus*).

The Ice-Bear (*Ursus maritimus*) may also be reckoned among the marine animals, as the sea affords him by far the greater part of his food. From the common bear, whom he surpasses in strength and size, as he attains a length of nine feet, and a height of four, he not only distin-

guishes himself by his white sleek-haired fur, but also by a much longer neck. His half-webbed feet show at once that he is born for a sea life, and he is able to swim three miles an hour, and to dive for a considerable length of time. On land he runs as fast again as a man, and often surprises his prey, as his tread upon the snow is almost inaudible. He principally lives on fish, but also on seals, birds, foxes, reindeer, and even attacks man—particularly when pinched with hunger. But in his turn he falls a prey to the inhabitants of the Arctic regions, who eat the flesh, though it is very coarse, and use the skin for coverings of various kinds. He is a cunning hunter, though not always successful. Thus one sunshiny day, Admiral Beechey saw a large walrus rise in a pool of water not very far from where he stood. After looking around, the grim-visaged creature drew his greasy carcase upon the ice, where he rolled about for a time, and at length laid himself down to sleep. A bear, which had probably been observing his movements, crawled carefully upon the ice on the opposite side of the pool, and began to roll about also, but apparently more with design than amusement, progressively lessening the distance that intervened between him and his prey. The suspicious walrus drew himself up, preparatory to a precipitate retreat, when immediately the bear remained motionless, as if in the act of sleep; but after a time he began to lick his paws, and clean himself, and occasionally to encroach a little more upon his intended victim. This time, however, his cunning was useless, for the walrus suddenly plunged into the pool, and though the bear, throwing off all disguise, rushed to the spot and followed him in an instant into the water, he was most likely disappointed of a meal that would have made up for a long period of fasting. The ice-bear is everywhere at home within the Arctic circle, and particularly abounds on Spitzbergen and the other small islands of that sea. He sometimes comes floating on drift ice to the north coasts of Iceland, Norway, and Newfoundland, but is soon killed by the inhabitants.

Seal.


Arctic Walrus.

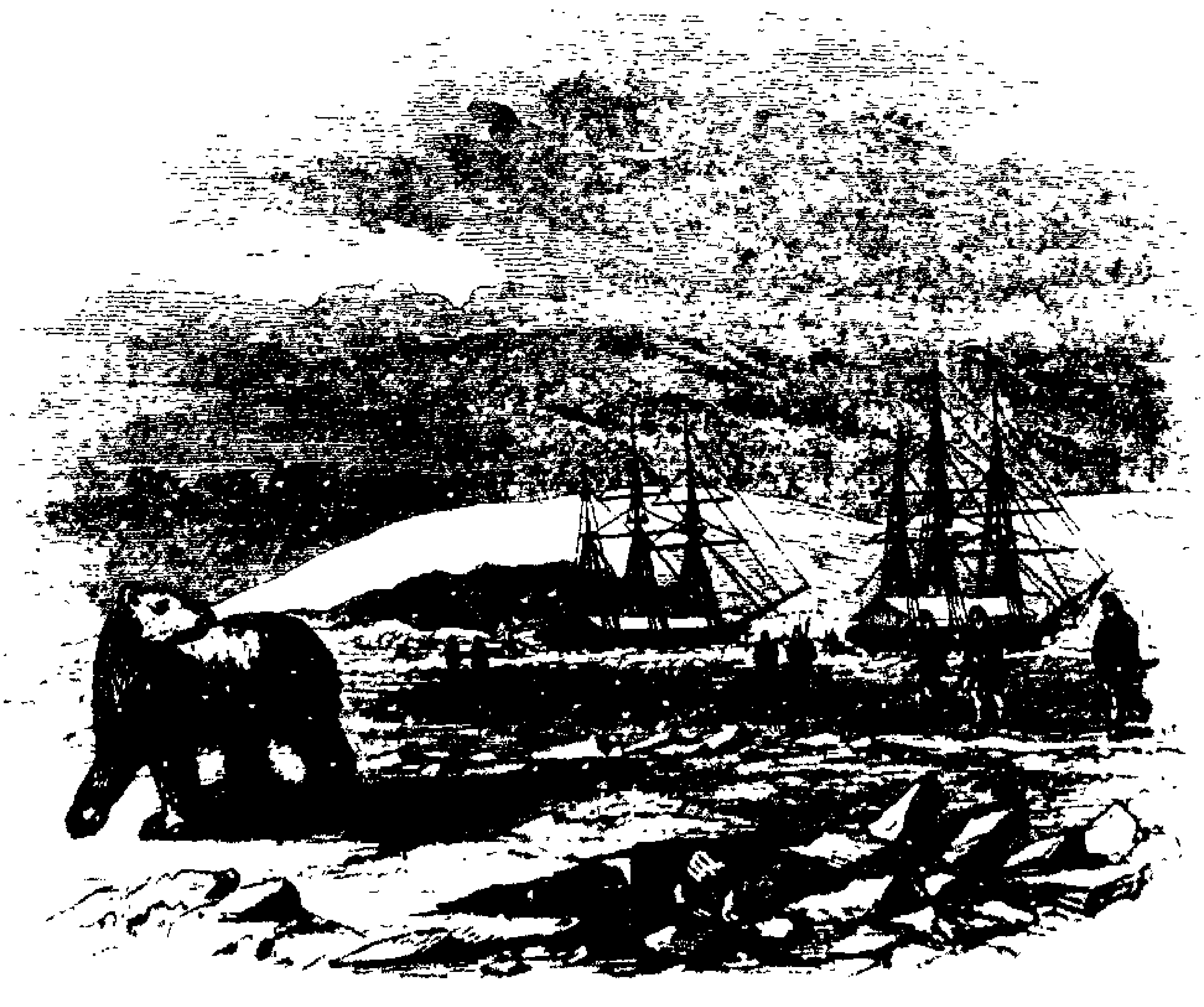
Manby, in his "Voyage to Spitzbergen," relates several interesting examples of his ferocity and daring. Having perceived an ice-bear swimming in the sea, a boat went after him to cut him off; when suddenly the monster changed his route, faced the boat, and approached it, keeping up a continued growling, with other indications of rage, such as showing his frightful teeth, and elevating his head and much of his body out of the water. Being desirous to preserve the head, Manby let him come within twelve yards, when he fired a ball through his shoulder, which deprived him of the use of a fore-leg. Roaring hideously, the infuriated animal pressed towards the boat in the most ferocious manner, endeavouring to board or upset it, but failed from the loss of his leg. He was then attacked by the crew with lances, the thrusts of some of which he avoided with astonishing dexterity, and, in the most resolute manner, again made several attempts to reach the boat; but being repulsed by the overpowering thrust of a lance from the harpooner on his flank, he was unable longer to continue the contest. He had bitten a lance, in the heat of the combat, with such exasperated rage, as to break one of his long tusks; but finding his efforts fruitless, he retreated towards the ice, swimming most astonishingly fast, considering the great propelling power he had lost, and finally ascended it with great difficulty, having only one fore-paw to assist him, when, exhausted by the effort, he fell down dead, uttering a tremendous growl.

Captain Lewis, with a party of five hunters, attacked a bear, and when at a distance of forty yards, four of them fired, and each lodged a musket ball in its body, two of which passed directly through the lungs. The enraged animal ran at them with open mouth, and as it came near, the two men who had reserved their fire gave it two wounds, and broke its shoulder, which retarded its motion for a moment. But before they could reload, it was so near that they were obliged to run, and before they reached the shore the bear had almost overtaken them. Two jumped into the canoe, the other four separated, concealed themselves behind ice blocks, and firing as fast as they could load, struck the bear several times. But although eight balls had passed through its body, the bear pursued two of them so closely, that they were obliged to leap down a perpendicular bank of twenty feet into the water. The dying

animal sprang after them, and was within a few feet of the hindermost, when his strength at last failed him.

Scoresby relates that in 1783, Captain Cook, of the Archangel, of Lynn, landed on the coast of Spitzbergen, accompanied by the surgeon and mate. While traversing the shore, the captain was unexpectedly attacked by a bear, which seized him in an instant between its paws. At this awful juncture, when a moment's pause must have been fatal to him, the unfortunate man called to his surgeon to fire, who immediately, with admirable resolution and steadiness, discharged his piece, and providentially shot the bear through the head, thus literally saving the master from the jaws of death.

"One evening," says Beechey, "we set on fire some sea-horse fat, in order to entice within reach of our muskets any bears that might be ranging the ice; as these animals possess a very keen scent, and are invariably attracted by burnt animal matter. About midnight we had the satisfaction of seeing one of them drag his huge carcass out of the water, and slowly make



Ice-bear approaching the "Dorothea" and "Trent."

his way towards us. The sight of the tall masts of the ships appeared to alarm him a little at first, for he occasionally hesi-

tated, threw up his head, and seemed half inclined to turn round and be off; but the agreeable odour of the burnt blubber was evidently so grateful to his olfactory nerves and empty stomach, that it overcame every repugnance, and gradually brought him within range of our muskets. On receiving the first shot he sprang round, uttered a terrific growl, and half raised himself upon his hind legs, as if in expectation of seizing the object that had caused him such excruciating pain; and woe to any human being who had at that moment been within reach of his merciless paws! The second and third ball left him writhing upon the ice, and the mate of the Dorothea jumped out of the vessel and endeavoured to despatch him with the butt end of a musket; but it unfortunately broke short off, and for a moment left him at the mercy of his formidable antagonist, who showed, by turning sharply upon his assailant, and seizing him by the thigh, that he was not yet mastered; and he would most certainly have inflicted a serious wound, had it not been for the prompt assistance of two or three of his shipmates who had followed him. The animal was by no means one of the largest of his species, being only six feet in length, and three feet four inches in height. His stomach was quite empty, with the exception of a garter, such as is used by Greenland sailors to tie up their boat stockings. In his left side there was a cicatrised wound of considerable magnitude. From what we saw of the activity and ferociousness of this animal, added to the well-known strength of his species, we readily gave credit to the accounts of Barentz and other early visitors to these regions; and it may be considered a fortunate circumstance for the hero of the Nile and Trafalgar that a natural barrier was interposed between him and the object of his chase, when in his youth he ventured alone over the ice in these regions in pursuit of such formidable game."

The ferocious white bear, the enemy and the dread of all other animals that come within its reach, is exceedingly tender and affectionate to its young, of which the following anecdote affords a striking and interesting example. While the "Carcase" was locked in the ice, early one morning the man at the mast-head gave notice that three bears were making their way very fast over the frozen ocean, and were directing their course towards the ship. They had no doubt been invited by the scent

of some blubber of a sea-horse that the crew had killed a few days before, which had been set on fire; for they drew out of the flames a part of the flesh that remained unconsumed, and ate it voraciously. The crew from the ship threw great lumps of the flesh of the sea-horse, which they had still left, upon the ice, which the old bear fetched singly, laid every lump before her cubs as she brought it, and dividing it, gave to each a share, reserving but a small portion to herself. As she was fetching away the last piece, they levelled their muskets at the cubs and shot them both dead, and in her retreat they wounded the dam, but not mortally. It would have drawn tears of pity from any but unfeeling minds, to have marked the affectionate concern expressed by this poor beast in the dying moments of her expiring young. Though she was herself dreadfully wounded, and could but just crawl to the place where they lay, she carried the lump of flesh she had fetched away, as she had done others before, tore it in pieces, and laid it before them; and when she saw that they refused to eat, she laid her paws first upon one and then upon the other, and endeavoured to raise them up, piteously moaning all the while. When she found she could not stir them, she went off, and when she had got at some distance, looked back and moaned; and that not availing her to entice them away, she returned, and smelling round them, began to lick their wounds. She went off a second time as before, and having crawled a few paces, looked again behind her, and for some time stood moaning. But still her cubs not rising to follow her, she returned to them again, and with signs of inexpressible fondness, went round one and round the other, pawing them and moaning. Finding at last that they were cold and lifeless, she raised her head towards the ship, and uttered a growl of despair, which the murderers returned with a volley of musket balls. She fell between her cubs, and died licking their wounds.

The Sea-Otter is the last of the marine mammiferous animals that claim our attention. Although it is also found in the southern Pacific, yet its chief resort is in the Behring's Sea, along the chain of the Aleut Islands. It is but a small animal, yet its long-haired, beautifully fine and black fur, which is not seldom paid for with 400 or 500 rubles, renders it by far the most important product of those seas. It has even got an his-

torical interest, since it has been the chief cause which led the Russians from Ochotzk to Kamtschatka, and from thence over the Aleüt chain to the opposite coast of America.

Sea-Otter.

The Aleut islanders show a wonderful dexterity in the capture of this animal. In April or May they assemble at an appointed spot in their light skin-boats, or *baidars*, and choose one of the most respected *tamols*, or chiefs, for the leader of the expedition, which generally numbers from fifty to a hundred boats. Such hunting-parties are annually organised from the Kurile Islands to Kadjack, and consequently extend over a line of three thousand miles. On the first fine day the expedition sets out, and proceeds to a distance of about forty wersts from the coast, when the baidars form into a long line, leaving an interval of about two hundred and fifty fathoms from boat to boat as far as a sea-otter diving out of the water can be seen; so that a row of thirty baidars occupies a space of from ten to twelve wersts. When the number of the boats is greater, the intervals are reduced. Every man now looks upon the sea with concentrated attention. Nothing escapes the penetrating eye of the Aleut; in the smallest black spot appearing but one moment over the surface of the waters, his experienced glance at once recognises a sea-otter. The baidar which first sees the animal, rows rapidly towards the place where the creature dived, and now the Aleut, holding his oar straight up in the air, remains motionless on the spot. Immediately the whole squadron is in motion, and the long straight line changes into a wide circle, the centre of which is occupied by the baidar with the raised oar. The otter not being able to remain long under water, reappears, and the nearest Aleut immediately greets him with an arrow. This first attack is seldom mortal; very often the missile does not even reach its over-distant mark, and the sea-otter instantly disappears. Again the oar rises from the next baidar; again the circle forms, but this time narrower than at first; the fatigued otter is obliged to come oftener to the surface, arrows fly from all sides, and finally

the animal, killed by a mortal shot, or exhausted by repeated wounds, falls to the share of the archer who has hit it nearest to the head. If several otters appear at the same time, the boats form as many rings, provided their number be sufficiently great. All these movements are executed with astonishing celerity and precision, and amidst the deepest silence, which is only interrupted from time to time by the hissing sound of the flying arrows.

Banded Dipper.

CHAP. X.

SEA-BIRDS.

Their vast Numbers. — Strand-Birds. — Artifices of the Sea-Lark to protect its Young. — Migrations of the Strand-Birds. — The Sea-Birds in General. — The Anatidæ. — The Eider Duck. — The Sheldrake. — The Loggerheaded Duck. — Auks and Penguins. — The Cormorant. — Its Use by the Chinese for Fish catching.—The Frigate Bird.—The Soland Goose.—The Gulls.—The Petrels.—The Albatross. — Bird-catching on St. Kilda. — The Guano of the Chincha Islands.

COUNTLESS are the birds of the wood and field, of the mountain and the plain; and yet it is doubtful whether they equal in number those of the fish-teeming seas. For every naked rock or surf-beaten cliff that rises over the immeasurable deserts of ocean, is the refuge of myriads of sea-birds; every coast, from the poles to the equator, is covered with their legions and far from land, their swarms hover over the solitudes of the deep. Many, unfit for swimming, seek their food along the shores; others rival the fishes in their own native element; and others, again, armed with indefatigable wings, pursue their prey upon the high seas. But, however different the mode of living and destination of the numerous tribes, families, genera, and species of the sea-birds may be, each of them is organised in the most perfect manner for the exigencies of its own peculiar sphere. Take, for instance, the Strand-birds, that live on the margin of ocean, and feast upon the molluscs and sea-worms, that inhabit

Flamingo.

PENGUINS ON THE SOUTH POLAR ICE.

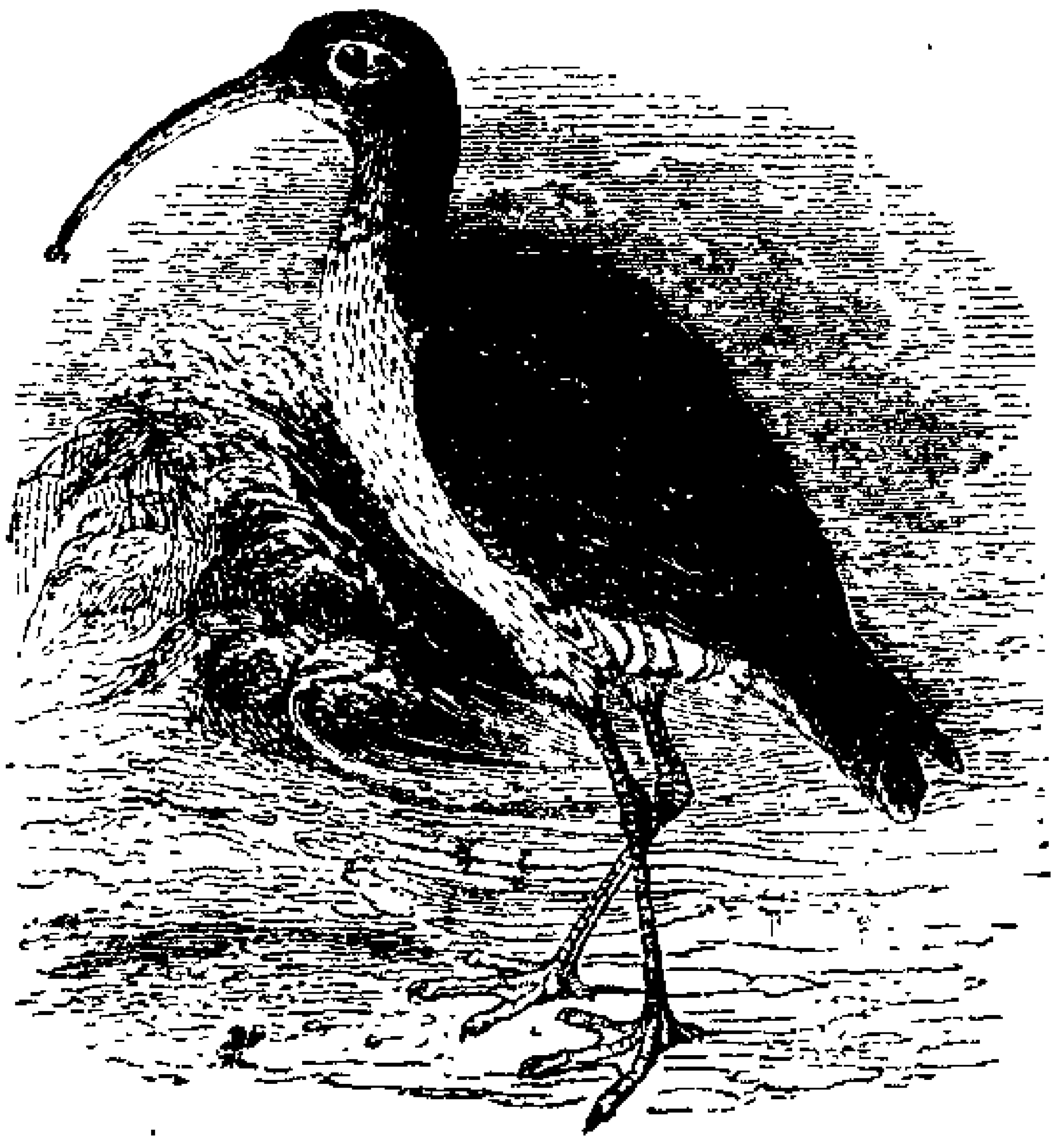
A SCENE showing the immense droves of penguins which often clothe the sea edges of the ice and rocks in the South Polar regions is represented in the annexed plate.

The individuals in the front are of the large species known as the Great Penguin, *Aptenodytes Forsteri*. Beyond is a group of the lesser, but perhaps more beautiful, species, *Aptenodytes Pennantii*.

In the distance are seen lines of another small kind, which has been made a separate genus, under the denomination of *Eudyptes*. It is inferior in characteristic beauty to either of the last named. *Eudyptes antipodes* is, however, worthy of a better representation than the dimensions of our plate permitted

PENGUINS ON THE SOUTH POLAR ICE.

the littoral zone. How admirably the light weight of their proportionally small body suits the soft, yielding soil on which they have to seek their food; how well their long legs are adapted for striding through the mud of the shallow waters; and their long bill and flexible neck, how beautifully formed for seizing their fugitive prey, ere it can bury itself deep enough in the safe mud or sand!

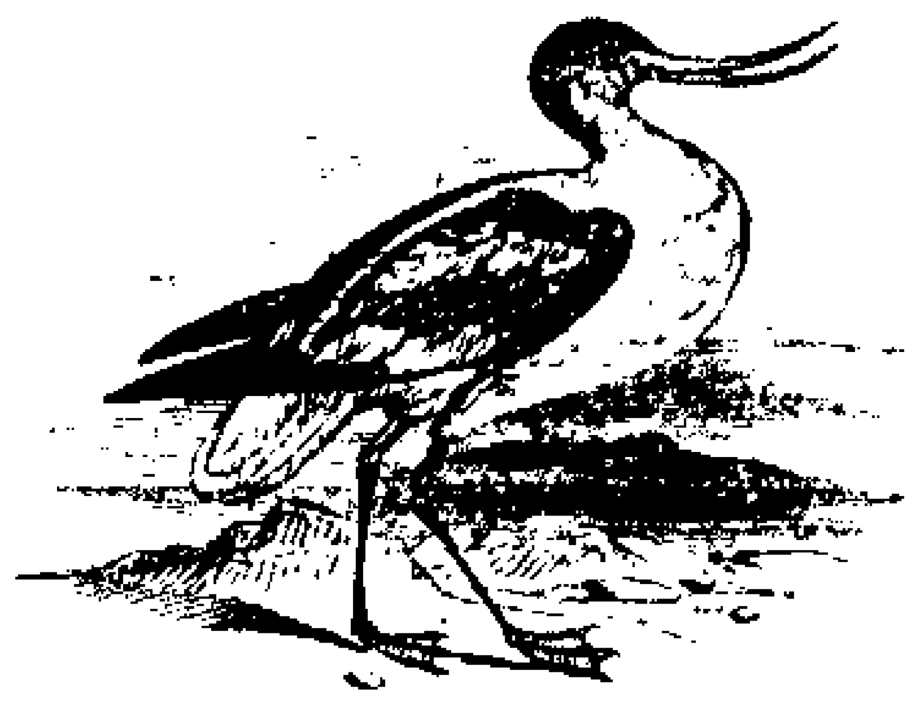


Curlew.

The wonderful art with which the feathered inhabitants of the grove construct their nests, we should in vain look for among the Strand-birds, but the anxiety they show in protecting their young brood, and the stratagèms they use to divert the attention of the enemy, are after all instincts no less admirable than those which prompt the Cassique or the Tailor-bird to build their complicated dwellings. Thus on the approach of any person to its nest, the Lapwing flutters round his head with great inquietude, and if he persists in advancing, it will endeavour to draw him away by running along the ground as if lame, and thereby inviting pursuit. The Golden Plover also, when it sees an enemy—man or dog—approach, does not await their arrival, but advances to meet them. Then suddenly rising with a shrill cry, as if just disturbed from its nest, it flutters along the ground as if crippled, and entices them farther and farther from its young. The dogs, expecting to catch an easy prey, follow the lame bird, which suddenly, however, flies off with lightning speed, and leaves its disappointed pursuers on the beach. The discovery of the nest is rendered still more difficult by the colour and markings of the eggs assimilating so closely to that of the ground and surrounding herbage.

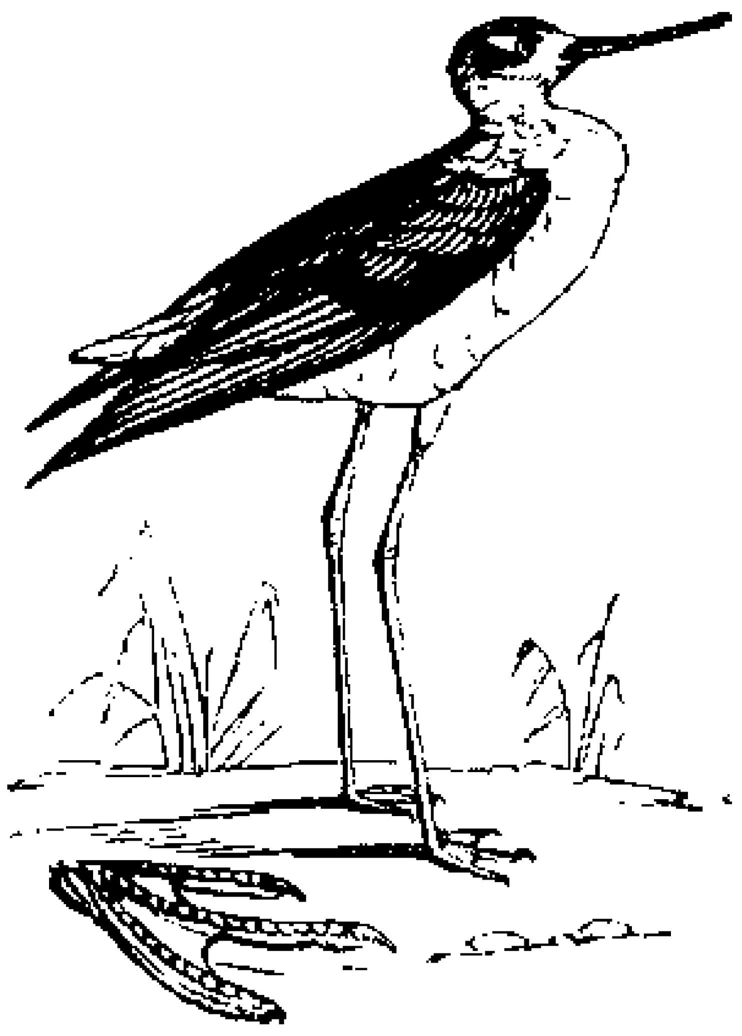
The Scoopers, Oyster-catchers, Avosets, and other strand-birds have recourse to similar stratagems for the protection of their young. In New Zealand, the French naturalists, Quoy and Gaimard, were deceived by an oyster-catcher, which, having

been shot at, feigned to be wounded, and with hanging wing, diverted them from the right track.



Avoset.

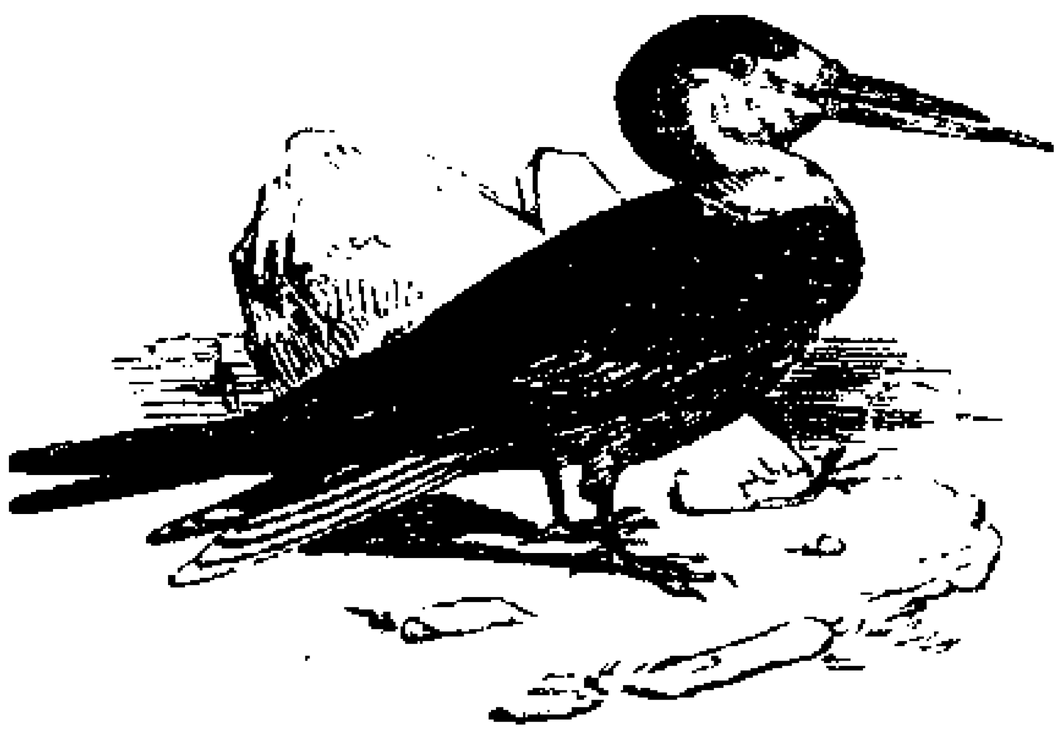
The strand-birds of the high northern regions fly from the winter to coasts where milder winds are blowing. But as soon as the summer's sun begins to exert its power, the desert shores of the Arctic Ocean become animated with swarms of plovers, sand-pipers, rails, herons, and phalaropes, to whom the thawed strand opens its inexhaustible supplies. Soon, however, the approach of winter hardens once more the soil, want follows upon abundance, and the whole long-legged host hastens to abandon the ice-bound strand, which opposes an impenetrable armour to their beaks.



Plover.

The food of the different kinds of strand-birds varies, and consequently their bills are variously formed. Those that live upon worms have generally a long thin awl-shaped bill, well fitted for picking their prey out of the soft muddy or sandy soil. If the small creatures conceal themselves under large stones, they are secure from these attacks; but then comes the Turn-stone, (*Tringa interpres*,) who with his bill, a little turned up at the top, raises the stone as with a lever, and makes sad havoc amongst the defenceless garrison.

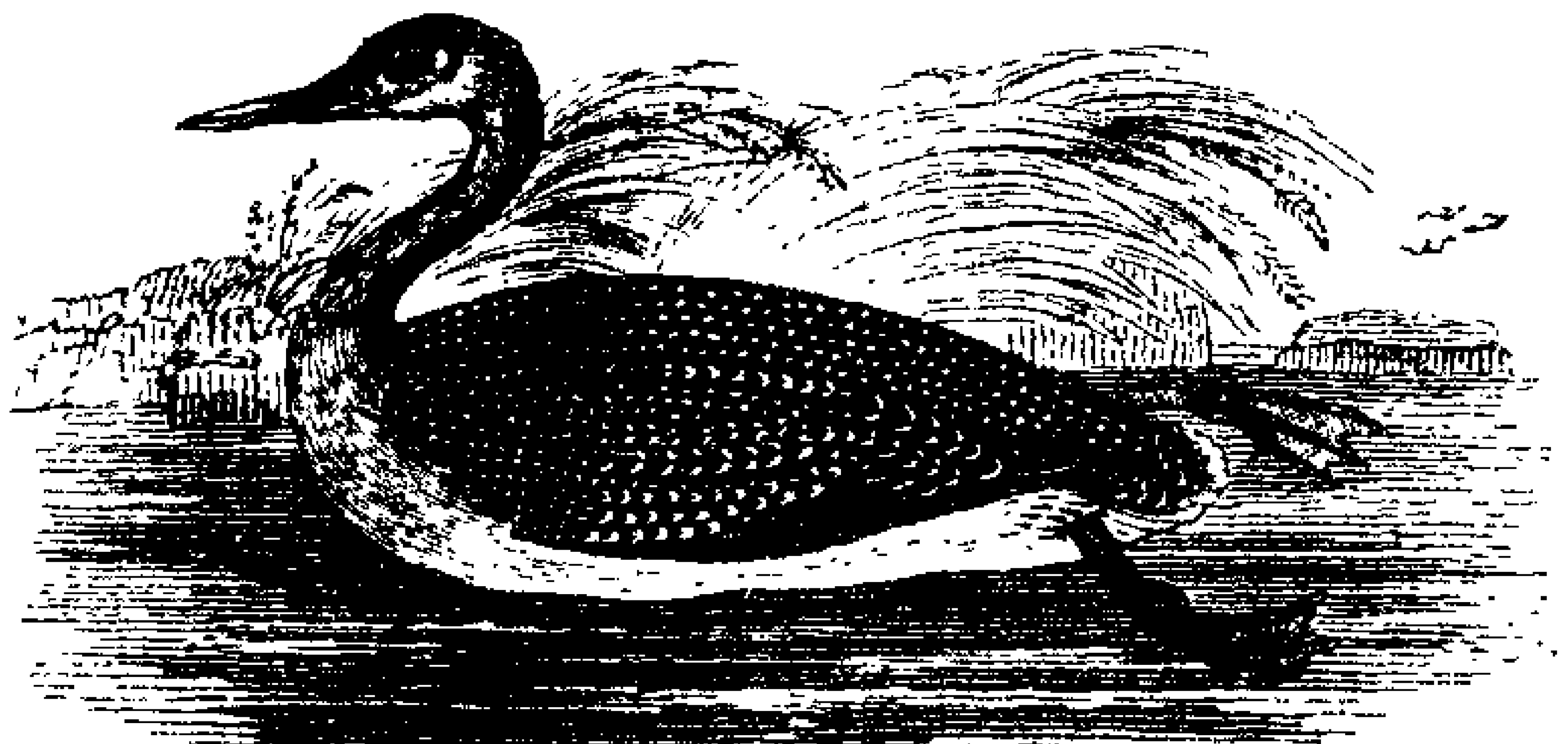
The Sea-pie uses its wedge-shaped bill for opening shell-fish with great adroitness; but the industry of the Black Skimmer or Cut-water, (*Rhynchops nigra*,) is still more remarkable. The bill of this bird, which chiefly inhabits the hot coasts of America, is quite unique in its kind; the under mandible, which is in fact nothing but a wedge, being about an inch longer than the upper one, by which it is clasp[ed]. The sandy beach of Penco, says



Scissor-bill (Rhynchops nigra).

Lesson, is full of shell-fish, which remain nearly dry at low water in small pools. The skimmer keeps waiting close by until one of them opens its shell, when he immediately introduces his wedge. He then seizes the mussel, beats it to pieces upon the sand, and devours it with all the pleasure of an epicure eating an oyster. He is also very active in sweeping the surface of the water, from which he skims, as it were, the smaller fish or shrimps. Thus, on all flat sandy shores nothing exists, either soft or hard, creeping or swimming, jumping or running, that does not find among the strand-birds its peculiar and admirably armed enemy, or that can boast of a perfect immunity from hostile attacks.

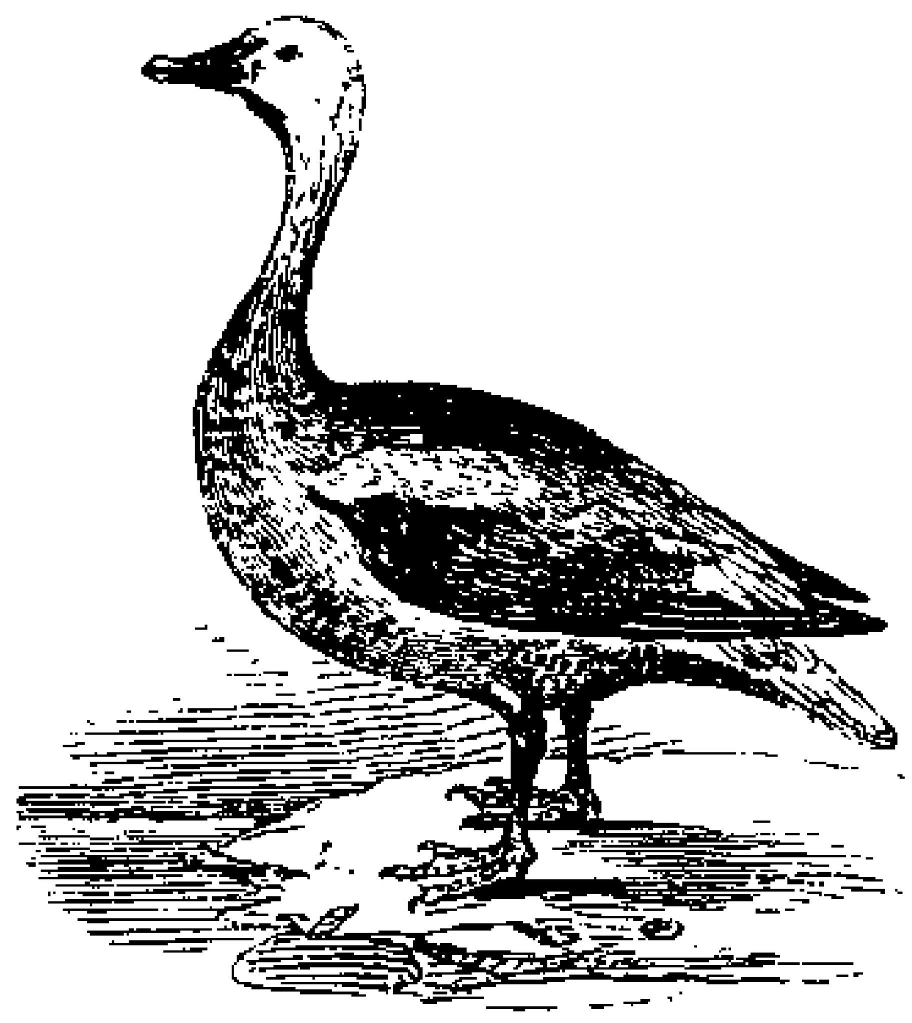
If we examine the real sea-birds, such as are formed for indefatigable swimming or diving, or for wide flights over the deserts of ocean, we shall find them no less wonderfully organised than the winged dwellers on the strand. Their short compressed toes easily cleave the waters, and by means of their membranes or webs form, as it were, broad oars. Their muscular



Speckled Diver.

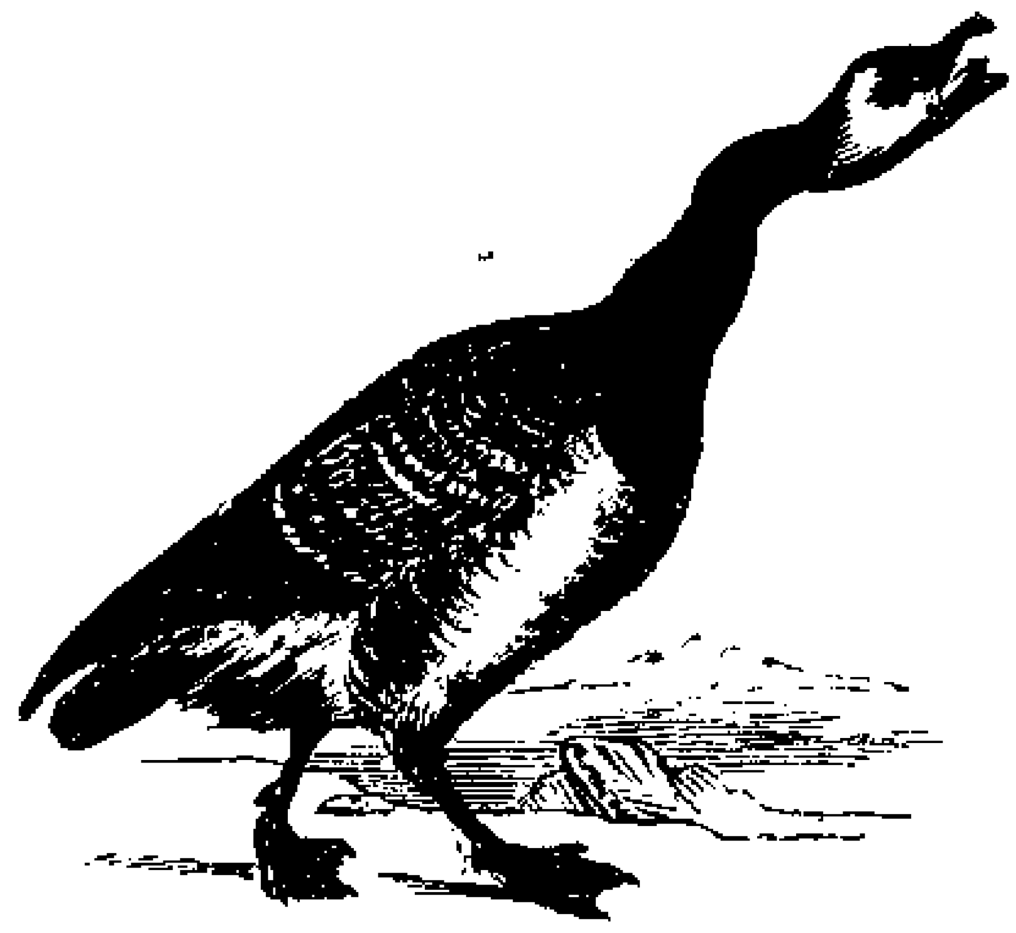
short legs, placed more behind than in other birds, are beautifully adapted for rowing, although their movements on land are awkward and slow. All creatures living on the sea of course require a thick waterproof mantle against weather and storm; and consequently we find the plumage of sea birds thicker, closer, and better furnished with down than that of the other feathered tribes. And finally, the gland which all birds have at the rump, and from which they express an oily matter to preserve their feathers moist, is most considerable among those that live upon the water, and contributes to make their plumage

impermeable. Surely the sea bird has no right to complain of imperfect clothing, or a deficient outfit!



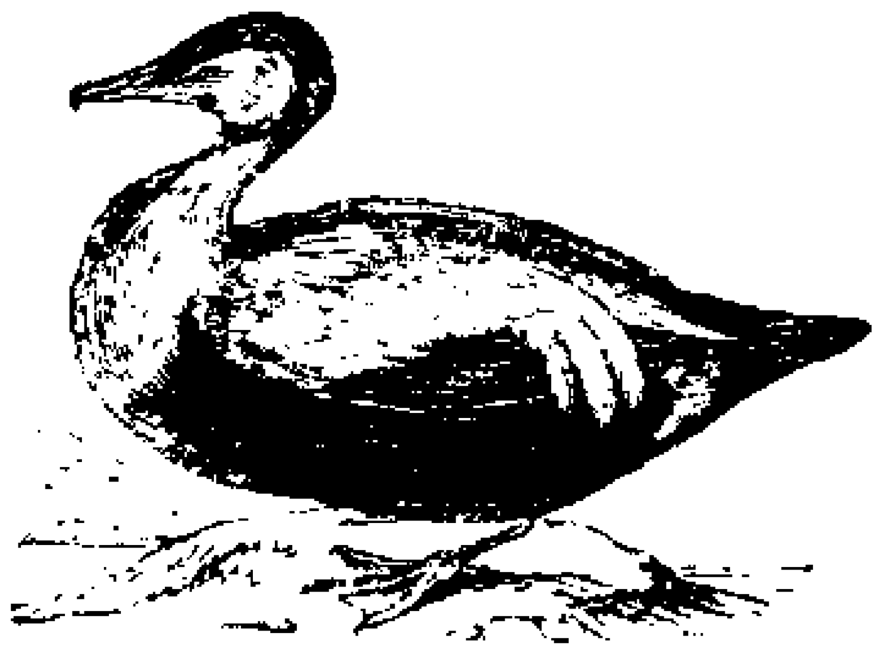
Snow Goose.

The numerous members of the duck family, or the Anatidæ, mostly live during the summer in higher latitudes, and wander in winter in countless swarms towards sunnier regions; as, for instance, the Snow Goose and the Barnacle. Some remain throughout the year in Great Britain, some only during the winter; while others, which are more particularly birds of the Arctic zone, but very seldom make their appearance in our southern clime. Most Anatidæ prefer the lake, the river, the pond, or the morass; but many of them are true littoral birds, and spend a great part of their time swimming and fishing in the sea.



Barnacle Goose.

The Eider Duck, (*Anas mollissima*,) which attains nearly double the size of the common duck, inhabits the higher latitudes of Europe, Asia, and America. One of its most remarkable breeding places is on the small island of Vidoe near Reikiavik (Iceland), where it lives under the protection of the law; a person who should chance to kill a breeding bird having to pay a fine of thirty dollars.



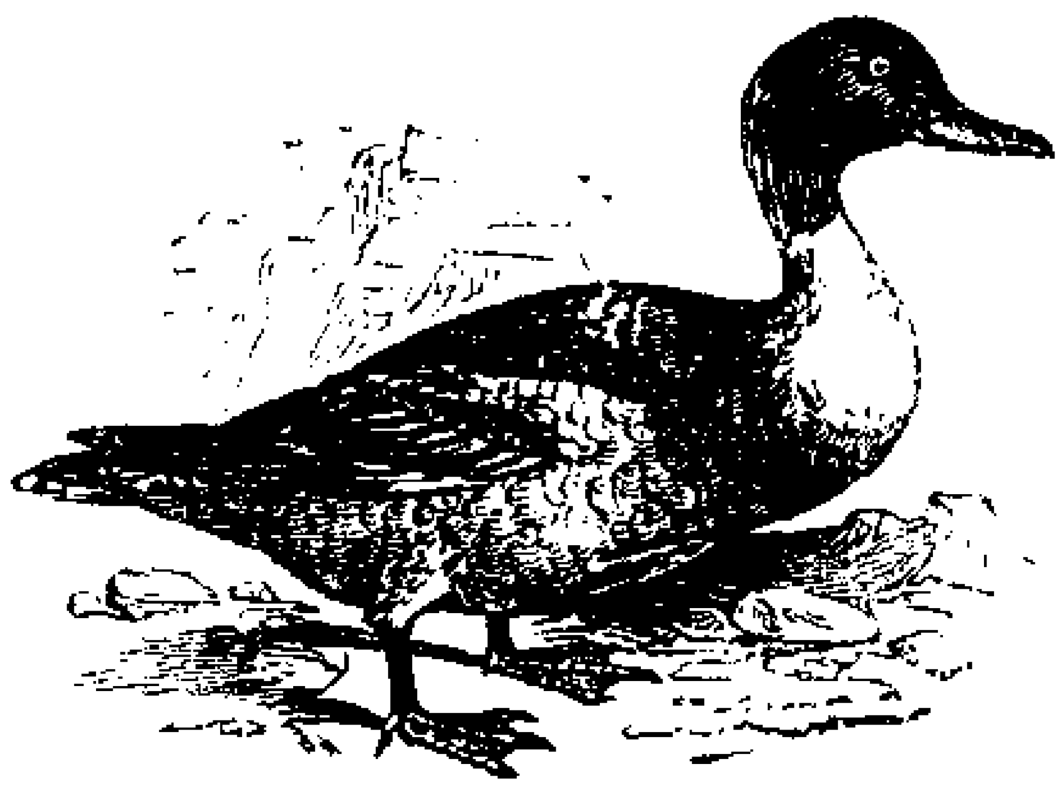
Eider Duck.

"As our boat approached the shore," says Mackenzie, ("Voyage through Iceland,") "we came through a multitude of these beautiful birds, who hardly gave themselves the trouble to move out of the way. Between the landing place and the house of the old governor the ground was covered with them, and it was necessary to walk cautiously not to tread upon their nests. The ganders went about with a cackle resembling the cooing of a pigeon, and were even more familiar than our common duck. Round about the house, on the garden wall, on the roofs, even in the inside of the huts and the chapel, they sat

breeding in great numbers. Those which had not been long upon their nest generally left it at our approach, but those which had more than one or two eggs remained undisturbed, allowed themselves to be handled, and sometimes even gently used their bills to remove our hand. The nests were lined with down, which the mother plucks from her own breast; and near at hand a sufficient quantity was piled up to cover the eggs when she goes to feed, which is generally at low water. The downs are twice removed, but sometimes the poor duck is obliged to provide for a fourth lining; and when she has no more to spare, the gander willingly deprives himself of part of his showy snow-white and rose-red garment. The eggs, which are considered a great delicacy, are also partially taken away. Our Vidoë friend used to send us two hundred at a time. When boiled, they are tolerably good, but always very inferior to those of our domestic hen. When taken from the nest, the downs are of course mixed with feathers and straw; and to sort and prepare them for sale is part of the winter employment of the women. One nest furnishes about a quarter of a pound of cleaned downs. The softness, lightness, and elasticity of these feathers is universally known. A few handfuls of compressed downs suffice to fill a whole coverlet, under which the northlander bids defiance to the strongest winter cold. Almost as soon as the young have left the egg, the mother conducts them to the water's edge, takes them on her back, and swims a few yards with them, when she dives, and leaves them on the surface to take care of themselves. As soon as they have thus acquired the art of swimming, the duck returns and becomes their leader. The broods often unite in great numbers, and remain some weeks quite wild, after which they disappear. Long before we left Iceland not a single duck was to be seen. No one knows to what parts they migrate. The bird is found on the Flannen Islands, to the west of Lewis; it is seen on the Shetland and Orkney Islands; it breeds on May Island, at the mouth of the Firth of Forth." Even on Heligoland the eider duck sometimes makes its appearance, but not to breed. The produce of the eider duck, either for personal use or as an article of trade, contributes to the comforts of many northern nations. The Esquimaux kill these birds with darts, pursuing them in their little boats, watching their course by the air

bubbles when they dive, and always striking at them when they rise wearied to the surface. Their flesh is valued as food, and their skins are made into warm and comfortable under garments.

The Long-tailed Duck and the Sheldrake or Burrow Duck, (*Anas glacialis; tadorna*), likewise inhabit the northern shores of Europe, Asia, and America. The former often remains the whole year in the high north, bidding defiance to the icy winter of the Arctic circle, and enjoying during the summer the light of an uninterrupted day. Often, however, it migrates to the south, and wanders from Greenland and Hudson's Bay as far as New York, and from Spitzbergen and Iceland to Heligoland and the Schleswig Islands. The duck likewise lines her nest with her downs. During the winter, the sheldrake is often seen in the west of England and in Ireland, where it is caught in nets. On Sylt, on the Danish coast, it is half domesticated, living in artificial burrows, and breeding even in the villages, on walls, and in earth holes. In a pleasant valley among the downs, which, although without trees, refreshed the eye with a verdant carpet variegated with flowers, Naumann, the celebrated German ornithologist, saw thousands of sheldrakes scattered in couples over the meads, so tame that they could be approached within twenty paces, when they flew up, but soon again alighted on the sward. He admired the construction of the artificial nests, often thirteen in one cavity, with a common entrance, and communicating by horizontal tunnels. Over every nest is a perpendicular opening, decked with a sod. On this being raised the duck is often seen sitting on her nest, so tame that it allows itself to be stroked. Every householder possesses several of these artificial burrows, from which he daily gathers during several weeks from twenty to thirty eggs, leaving six in each nest to be hatched. He also takes care to remove one half of the beautiful downs, which are no less light and valuable than those of the eider duck.


Sheldrake.

One of the most curious members of the duck family is the large Logger-headed Duck or goose (*Anas brachyptera*) of the Falkland Islands, which sometimes weighs twenty-two pounds.

It was formerly called, from its extraordinary manner of paddling and splashing upon the water, race-horse, but is now named, much more appropriately, steamer. Its wings are too small and weak to allow of flight, but by their aid, partly swimming and partly flapping the surface of the water, it moves very quickly. The manner is something like that by which the common house duck escapes when pursued by a dog; but Mr. Darwin, who often watched the bird, is nearly sure that the steamer moves its wings alternately, instead of both together, as in other birds. These clumsy logger-headed ducks make such a noise and splashing, that the effect is exceedingly curious. It is able to dive only a very short distance. It feeds entirely on shell-fish from the kelp and tidal rocks; and hence its beak and head, which it uses for the purpose of breaking them, are so surprisingly heavy and strong, that they can scarcely be fractured with a hammer.

Another remarkable inhabitant of the southern hemisphere is the Rock Goose, (*Anas antarctica,*) which exclusively inhabits rocky shores, and is often met with on the Falkland Islands, and on the west coast of America, as far north as Chili. In the deep and retired channels of Tierra del Fuego, the snow-white gander, invariably accompanied by his darker consort, and standing close by each other on some distant rocky point, is a common feature in the landscape.

The Mergansers differ chiefly from the sea-ducks, whom they otherwise closely resemble both in outward form and mode of life, by their comparatively long and slender bill, furnished with serrated edges and hooked at the extremity. All the British species are adorned with crests, or a tuft of long feathers, at the back of the head. The red-breasted merganser is a beautiful bird, painted with a variety of gay colours. "The head and throat are of a rich shining green, the neck white, except a narrow dark line behind; at either side before the wings are numerous large white feathers bordered by velvet-black; the lower part of the neck and breast is chestnut-brown, varied with dark streaks, and

Red-Breasted Merganser.

the body and wings are elegantly diversified with white, black, and brown feathers." (Harvey, *Sea Side Book.*)

The family of the Grebes and Divers approximates the duck tribe in the order of creation, but is distinguished by a long conical bill, and the position of the legs, which are placed so far back towards the tail, that when the bird leaves the water it is obliged to stand nearly erect to preserve its equilibrium. The

Great Crested Grebe.

foot in the grebes is only partially webbed, the toes being merely lobed or finned; but the divers are completely web-footed, like the duck. These latter do honour to their name, being most expert and indefatigable divers, remaining down sometimes for several minutes, and swimming rapidly under the water. The Red-throated Diver preys much on the fish entangled in the nets, but is often caught himself in his rapid pursuit of the fish; thus affording a strange example of a bird caught under water.

The Arctic Diver enjoys among the Norwegians the reputation of being a most excellent weather-prophet. When the skies are big with rain, the birds fly wildly about, and make the most horrible hoarse noise, fearing that the swelled waters should invade their nest; on the contrary, in fine weather, their note is different, and seemingly in an exulting strain. For this

reason, the Norwegians, who, being mostly a maritime population, pay the greatest attention to the aspect of the sky, think it impious to destroy, or even to disturb, this species.

The family of *Alcadæ*, comprising the Guillemots, Auks, Razor Bills, and Puffins, is in form of body very similar to the Divers: the legs, which are short and thick, are inserted very far back, and give a still more erect carriage to the bird when on shore. The wings are short and small in proportion to the bulk of the body, and in the (now probably extinct) Great Auk, so much so as to be unfitted for flight. The Auks are strictly sea-birds, and nestle on its borders, breeding in caverns and rocky cliffs, and laying only one large egg. They obtain their food by diving, at which they are very expert. They are of social habits, and congregate in vast flocks on the rocky islets and headlands of the northern coasts. At the head of the Magdalen Bay, on Spitzbergen, for instance, there is a high pyramidal mountain of granite, termed Rotge Hill, from the myriads of small birds of that name (Little Auk, *Alca alce*), which frequent its base, and which appear to prefer its environs to every other part of the harbour. They are so numerous that Admiral Beechey frequently saw an uninterrupted line of them extending full half-way over the bay, or to a distance of more than three miles, and so close together that thirty fell at one shot. This living column, on an average, might have been about six yards broad, and as many deep; so that allowing sixteen birds to a cubic yard, there must have been nearly four millions of birds on the wing at one time.

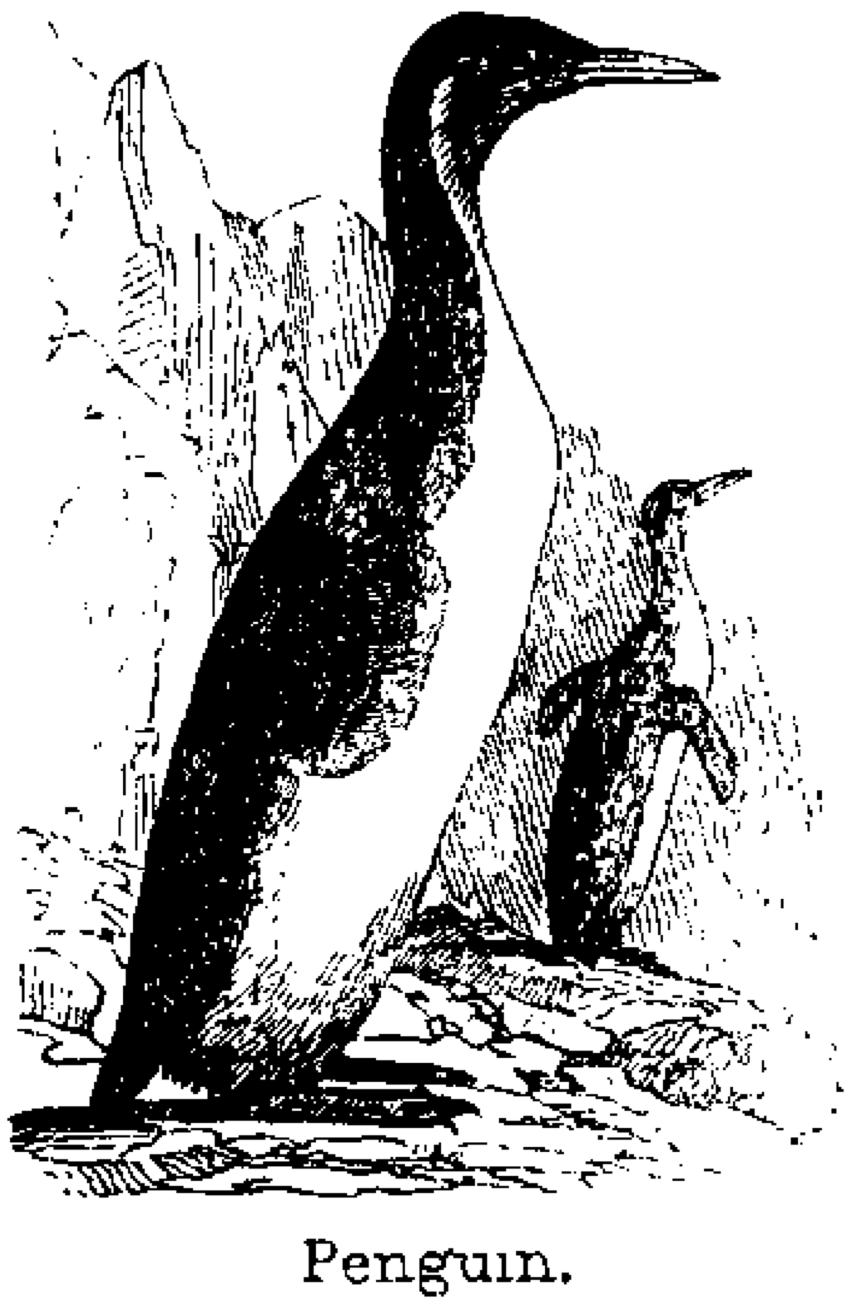
The calling or crying of the rotges amongst one another sounds at a distance as if you heard a great many women scolding together; so that the noise of millions uniting in a chorus must be terrific. On a fine summer's day, when a glorious sunshine gilds the snow peaks and glaciers of Spitzbergen, the merry cry of the little auk unites with that of the willocks, divers, cormorants, gulls, and other aquatic birds; and everywhere groups of walruses, basking in the sun, mingle their playful roar with the husky bark of the seal. It is pleasant to reflect that in those arctic wilds, uninhabitable by man, there are still millions of creatures enjoying life, all owing their support to the inexhaustible "garners" of the deep.

In the Penguins of the southern hemisphere, the shortness of

wing and aptitude for swimming and diving are still more conspicuous than in the auks of the northern regions. In the water, the penguin makes use of its small featherless wing-stumps as paddles; on land, as fore feet, with whose help it scales so rapidly the grass-grown cliffs, as to be easily mistaken for a quadruped. When at sea, and fishing, it comes to the surface for the purpose of breathing, with such a spring, and dives again so instantaneously, that at first sight no one can be sure that it is not a fish leaping for sport. Other sea-birds generally keep part of their body out of the water while swimming; but this is not the case with the penguin, whose head alone appears upon the surface; and thus it swims with such rapidity and perseverance, as almost to defy many of the fishes to equal it. How much it feels itself at home on the waters, may be inferred from the fact that Sir James Ross once saw two penguins paddling away a thousand miles from the nearest land.

Antarctic Penguin.

On many uninhabited islands in the higher latitudes of the southern hemisphere, this strange bird is met with in incredible numbers. On Possession Island, for instance, a desolate rock discovered by Sir James Ross in lat. 71° 56′, not the smallest appearance of vegetation could be found; but inconceivable myriads of penguins completely and densely covered the whole surface of the island, along the ledges of the precipices, and even to the summits of the hills, attacking vigorously the sailors as they waded through their ranks, and pecking at them with their sharp beaks, disputing possession, which, together with their loud coarse notes, and the insupportable stench from the deep bed of guano which had been forming for ages, made them glad to get away again. Sir James took possession of the island in the name of Queen Victoria; but unfortunately its treasures of manure are hidden beyond a far too formidable barrier of ice ever to be available to man.



Penguin.

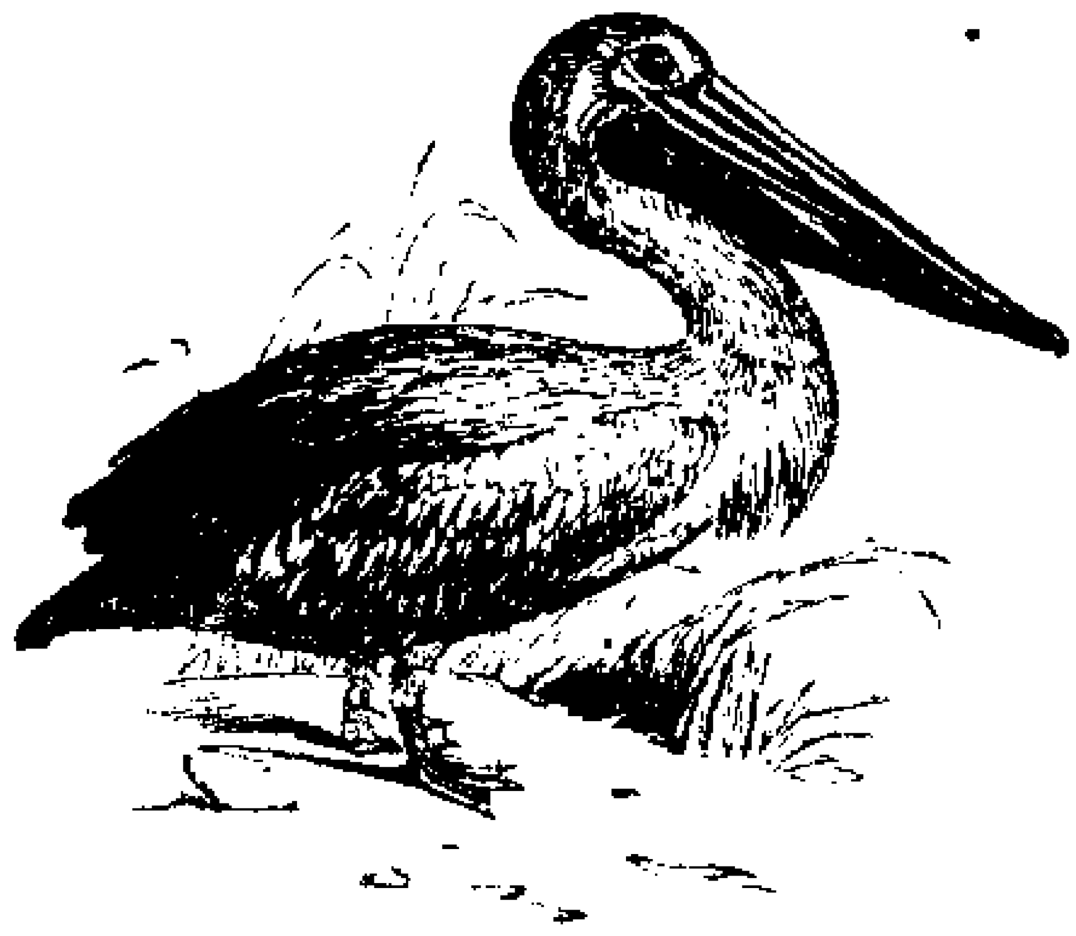
Duperrey ("Voyage de la Coquille,") found the Falklands swarming with penguins. In summer and autumn these strange birds leave their burrows early in the morning, and launch into the sea for fishing. After having filled their capacious stomachs, they waddle on shore, and remain for a time congregated on the strand, raising a dreadful clamour; after which they retire to enjoy a noon-tide sleep among the high tussack grass or in their burrows. In the afternoon the fishing recommences. Lesson says that about sunset on fine summer evenings, which unfortunately are but of rare occurrence on those foggy, storm-visited islands, all the penguins together raise their discordant voices, so that at a distance the noise might be mistaken for the hoarse murmur of a great popular assembly. As soon as the young are sufficiently strong, the whole band leaves the island, departing no one knows whither, though the mariners frequenting those seas believe that they spend the winter on the ocean. This opinion seems to be corroborated by the observations of Sir James Ross, who, on the 4th of December, in 49° S. lat., met on the high sea a troop of penguins that were doubtless on the way to their breeding place. He admired the astonishing instinct of these creatures, half fish, half bird, which leads them hundreds of miles through the pathless ocean to their accustomed summer abodes.

It may be imagined how the neighbouring seas must abound with fish, to be able to nourish such multitudes of penguins, whose stomach is capable of holding more than two pounds, and whose voracity is so great that they are often obliged to disgorge their superabundant meal. The elongated stomach reaches to the lower part of the abdomen, and the whole length of the intestinal canal is twenty-five feet, fifteen times longer than the body, so that nature has evidently provided for a most vigorous appetite, whetted by sea-bathing and sea air.

There are several species of penguins. The largest (*Aptenodytes antarctica)* weighs about eighty pounds. It is a rare bird, generally found singly, while the smaller species always associate in vast numbers. In 77° S. lat., Sir James Ross caught three of these giant penguins, the smallest of which weighed fifty-seven pounds. In the stomach of one of them he found ten pounds of quartz, granite, and trap fragments, swallowed most likely to promote digestion.

The penguin, like his northern representative the auk, lays but one single egg. His not unsavoury flesh is black. Besides his dense plumage, he is protected against the cold of the higher latitudes by a thick cover of fat under his skin.

Humboldt's penguin (*Spheniscus Humb.*) is frequently found in the Bay of Callao. This bird is a little smaller than the common grey penguin, with a somewhat differently coloured back and breast. The Peruvians call it *pajaro niño*, "little darling bird," and keep it in their houses; it is very easily tamed, gets very familiar, and follows its master like a dog. The sight of the fat creature, awkwardly waddling about the streets on its short feet, and violently agitating its wing-stumps to maintain its equilibrium, is inexpressibly grotesque. Tschudi kept one of these tame penguins, which punctually obeyed his call. At dinner it regularly stood like a stiff footman behind his chair, and at night slept under his bed. When "Pepe" wanted a bath, he went into the kitchen and kept striking with his beak against an earthen jar, until some one came to pour water over him.

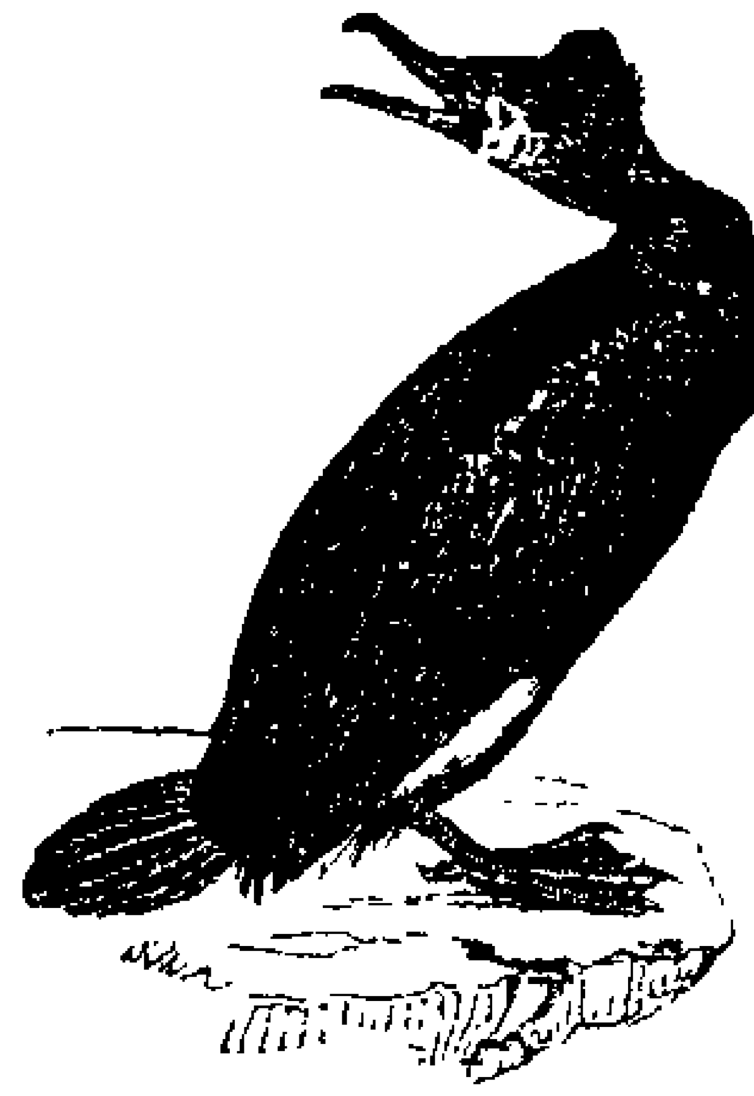


Common Pelican.

To the pelican tribe, which is generally distinguished by a surface of naked skin about the throat, capable of considerable dilatation, and serving as a pouch for the reception of unswallowed food, belong among others the Cormorant (*Phalacrocorax*), the Frigate-Bird (*Tachypetes aquila*), and the Gannet (*Sula bassana*), or Solan goose. All these birds are of much more active habits than the last named family, with bodies of more shapely form, more ample wings, and a stronger flight.

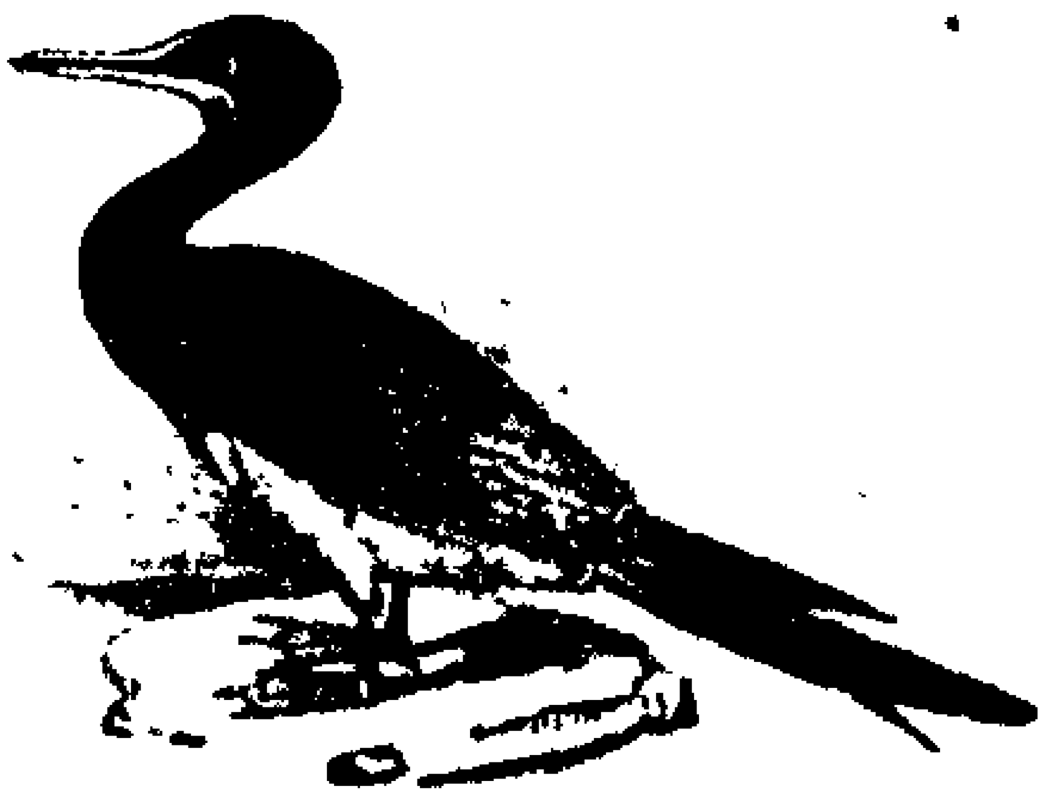
The common cormorant with his long bill, bent at the point, and furnished with a nail, his black livery, and yellowish chin-pouch, is a most disagreeable comrade. His smell, when alive, is more rank and offensive than that of any other bird, and his flesh is so disgusting, that it turns the stomach even of an Esquimaux In spite of his voracity, he always remains thin and meagre, the picture of a hungry parasite. But fishing he understands remarkably well, and formerly used to be trained

for this purpose in England, in the same manner as a nearly related species is to the present day employed in China. Mr. Fortune thus describes this original chase, which he witnessed on the Yellow River:—"There were two boats, each containing one man, and about ten or twelve birds. The latter stood perched on the sides of the boats, and seemed to have just arrived upon the scene of action. Their masters now commanded them to leave the boats; and so excellent was their training, that they instantly obeyed, scattered themselves over the canal, and began to look for prey. They have a splendid sea-green eye, and quick as lightning they see and dive upon the finny tribe, which, once caught in the sharp notched bill, finds escape impossible. As soon as a cormorant rises to the surface with his prey in his bill, his master calls him, when, docile as a dog, he swims to the boat and surrenders the fish, after which he again resumes his labours. And what is more wonderful still, when one of them has got hold of a fish so large as to be with difficulty dragged to the boat, the others come to his assistance, and by their united strength overpower the sprawling giant. Sometimes when a cormorant is lazy or playful, and seems to forget his business, the Chinaman strikes the water with a long bamboo near to the dreamer, and calls out to him in an angry tone. Immediately the bird, like a schoolboy caught nodding over his lesson, gives up his play, and returns to his duty. A small string is tied round the neck of the birds, for fear they might be tempted to swallow the fish themselves."



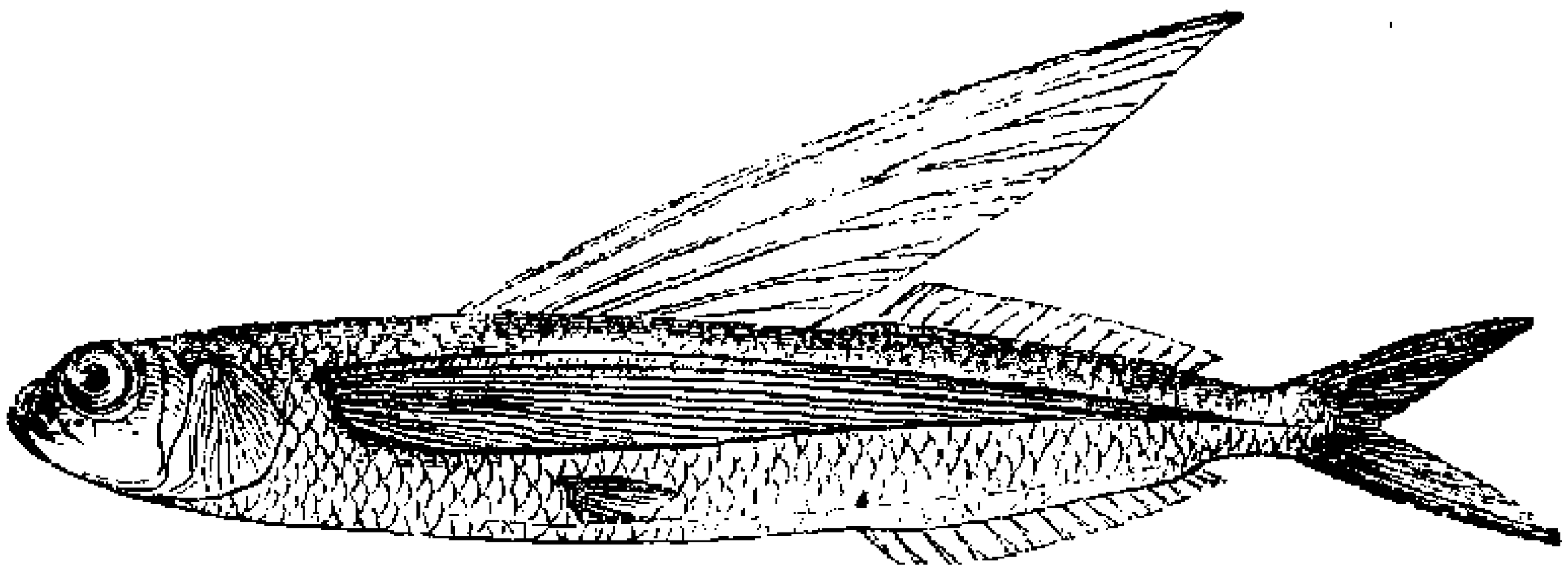
Common Cormorant.

The frigate-bird hovers over the tropical waters. Its singularly easy and graceful flight affords all the charm of variety. Sometimes it is seen balanced in mid air, its wings spread, but apparently motionless, its long forked tail expanding and closing with a quick alternate motion, and its head turned inquisitively downwards; sometimes



Frigate-Bird.

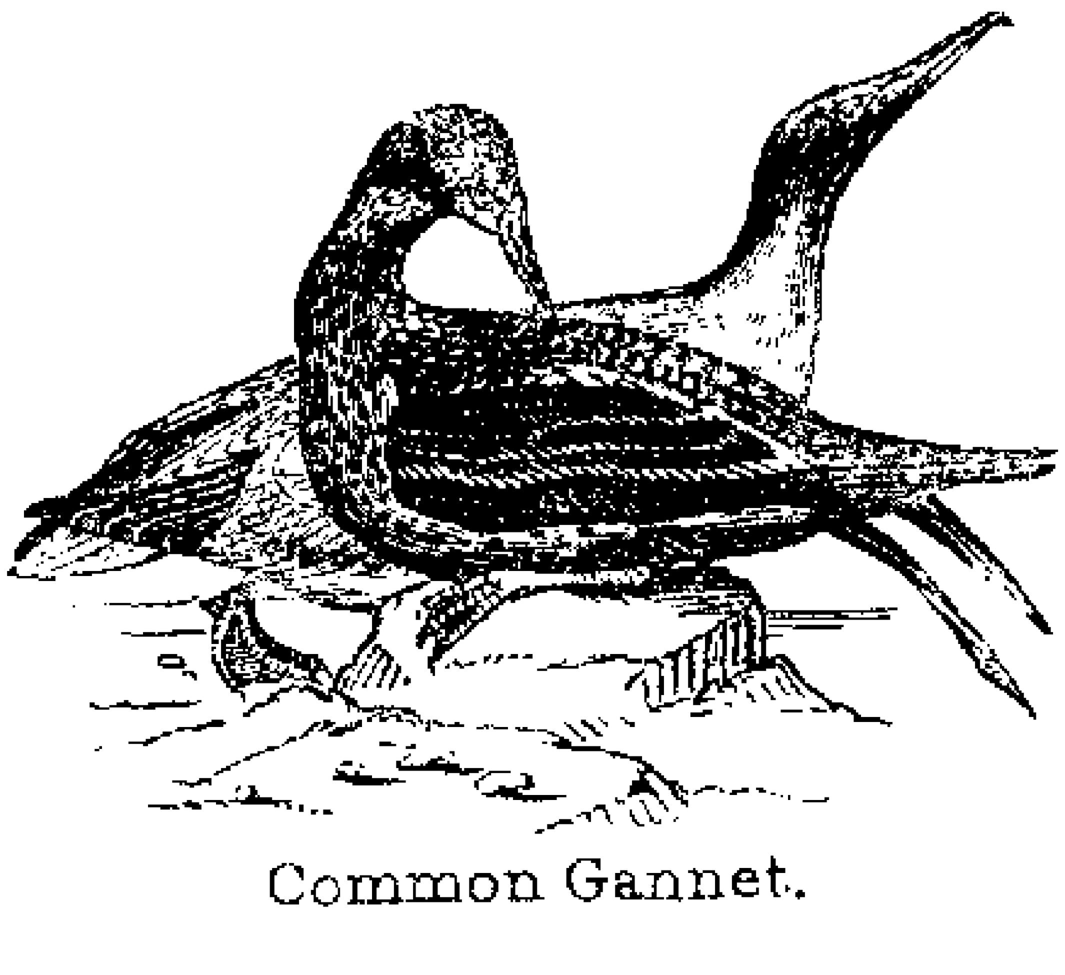
it wheels rapidly, and darts to the surface of the water in pursuit of prey; and then again it soars so as to be lost to vision, its elevation alone being sufficient to distinguish it from all other sea birds. Sometimes it is seen 400 leagues from land; and yet it is said to return every night to its solitary roost. Its expanded pinions measure from end to end fourteen feet, a prodigious extent of wings, equalling or even surpassing that of the condor, the lordly bird of the loftiest Andes. Being unable to swim or dive, it seizes the flying-fish, that, springing out of the water to avoid



Flying Fish.

the jaws of the bonito, often falls a prey to the frigate-bird, or else it compels boobies or tropic birds to disgorge. On volcanic coasts it builds its nest in the crevices of the high cliffs, and on the low coral islands in the loftiest trees. In the Paumotu Group, Captain Wilkes saw whole groves covered with the nests of the frigate-bird. When the old birds flew away, they puffed up their red pouches to the size of a child's head, so that it looked as if a large bladder full of blood was attached to their neck.

The Gannet or Soland-goose (*Sula Bassana*) haunts the Bass Island, a high steep rock in the Frith of Forth, whose black precipices are painted with dazzling stripes of white *guano*, the product of the inconceivable number of birds which settle upon the weather-beaten ledges. The gannets incubate in the turf of the slopes above, and you may sit down by them and their great downy young while their mates hover over you with discordant screams and



Common Gannet.

almost touch you with their outspread pinions. There is but one landing-place, and this sole entrance to the natural fastness is closed by a barred gate, proclaiming that man has taken possession of the rock. Some years ago it was let at an annual rent

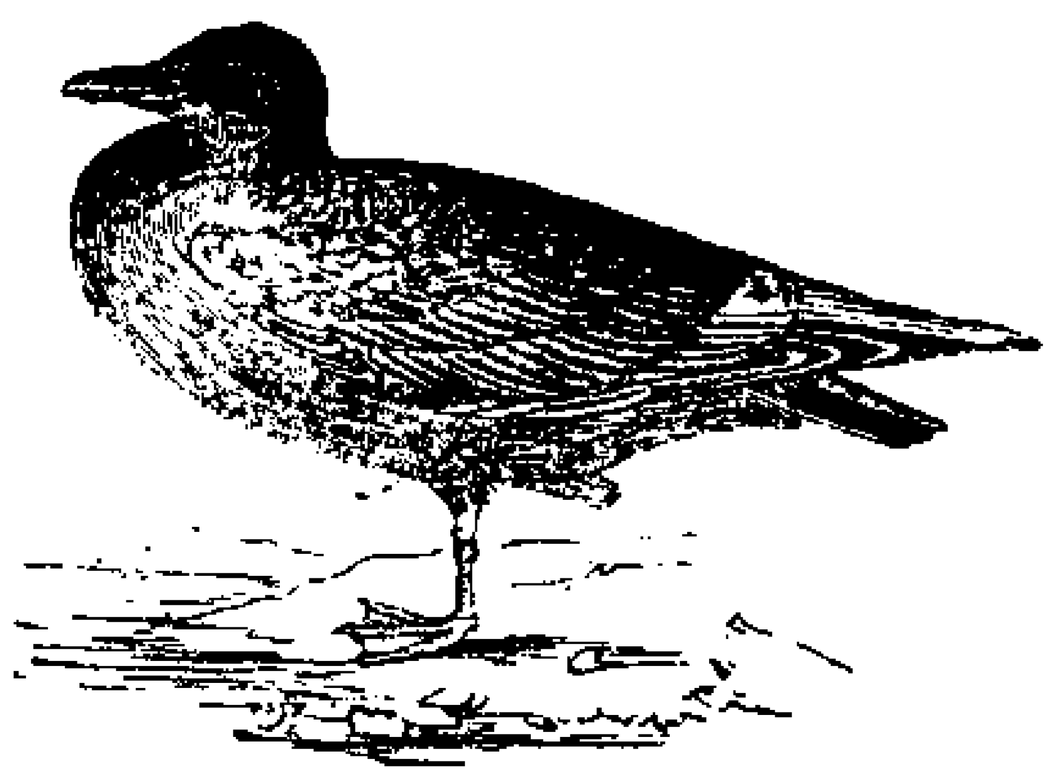
of thirty-five pounds. The eggs are not collected, and no old bird is allowed to be shot, under a penalty of five pounds; only the young birds are persecuted. The chase begins on the 1st of August. They are taken with the hand or knocked on the head with sticks, and sent to the Edinburgh market, where they fetch about half a crown a piece. The gannet breeds also on Lundy Island, in the Severn, on Ailsa, on the coast of Ayrshire, on the island of St. Kilda, and hardly anywhere else in Europe. As it must let itself fall before taking wing, it requires a steep and precipitous breeding-station. Its mode of fishing is particularly graceful. Rapidly skimming the surface of the sea, as soon as it spies a fish swimming below, it rises perpendicularly over the spot, and then, suddenly folding its wings, drops head-foremost on its prey swifter than an arrow, and with almost unerring aim. The prevalent colour of the full-plumaged bird is white, the tips of its wings only being black, and some black lines about the face, resembling eyebrows or spectacles. The pale yellow eyes are encircled with a naked skin of fine blue, the head and neck are buff colour, the legs black, and greenish on the fore part. The plumage of the young bird is very different, being blackish, dotted irregularly with small white specks.

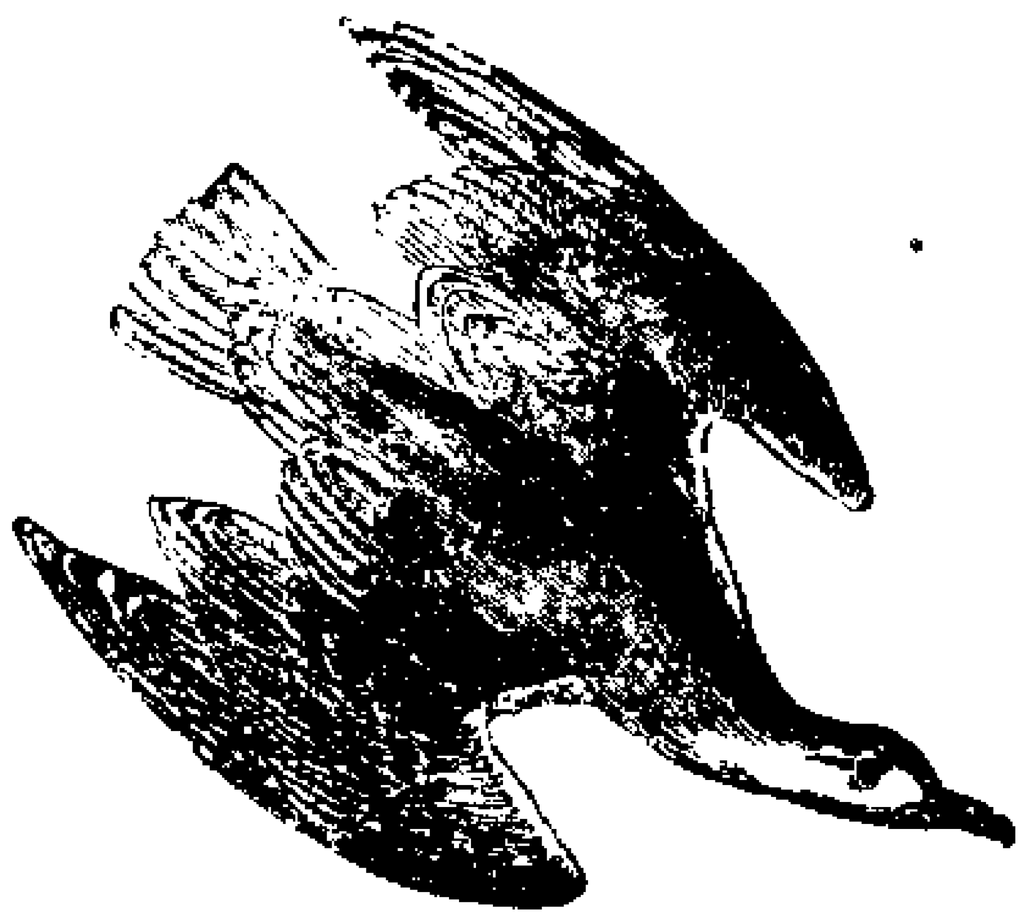
The family of the Laridæ, which comprises the gulls, the sea-swallows, the petrels, and the albatrosses, is widely spread over the whole surface of the ocean. All the birds of this tribe have a powerful flight, and are distinguished by the easy grace of their motions, striking the air at long intervals with their wings, and generally gliding or soaring with outstretched pinions. Their form is handsome and well-proportioned, some of them resembling the swallow, others the dove; but their mode of life does not correspond with their beauty, as they are all ill-famed for their predatory habits and insatiable voracity. The cry of the sea-mew is peculiar, being a mixture of screaming and laughing. When in the solitude of a wild rocky coast it is heard mingling with the hoarse rolling of the surge and the moaning wind, it harmonises well with the character of the dreary scene, and produces a not unpleasing effect. It is amusing to witness the movements of the sea-mews at the mouths of the larger rivers, where they are seen in numbers, picking up the animal substances which are cast on shore, or come floating down with the ebbing tide. Such as are near the breakers will mount up the surface of the water, and run

splashing towards the crest of the wave, to get hold of the object of their pursuit, while others are seen every now and then diving, and reappearing with a fish in their bill. Sometimes the more powerful sea-hawk interrupts their pleasure, pounces upon the robbers, and scatters the screaming band.

Many different species of gulls inhabit the northern shores, and various are the places which they choose for breeding. The Kittiwake or Tarrock (*Larus tridactylus*), one of the commonest sea-birds in Greenland, Iceland, the Feroës and the Scotch islands, builds its sea-weed nest on the highest and most inaccessible rocks. According to Faber (Prodromus of Icelandic Ornithology), its swarms are so numerous on Grimsoe, that they darken the sun when they fly, deafen the ear when they scream, and deck the green-capped rocks with a white covering when they breed.

In the famous "bird-city" at the north point of Sylt, the Silvery or Herring-gull plays a prominent part. Its great size, equal to that of the raven, but with much longer wings—its agreeable form, its pure white plumage, of metallic brilliancy on the back, gradually melting into light ash-blue; the velvet-black ends of the wings, with snowy feather tips, the lovely yellow eye, and the deep yellow beak, with its coral-red spot, all this together forms a beautiful picture. "There we stood," says Naumann, "surrounded by thousands, that partly hovered close over our heads, uttering their shrill screams, partly stood before us in pairs; some on their nests, the males keeping guard, some sleeping on one leg, and others leisurely stretching themselves. In one word, one hardly knew what most to admire, the uncommon cleanliness and beauty of their plumage, the great variety and elegance of their attitudes, their tameness, or the immense numbers collected in so small a space."


Herring Gull (Young).


Herring Gull, or Silvery Gull (Adult).

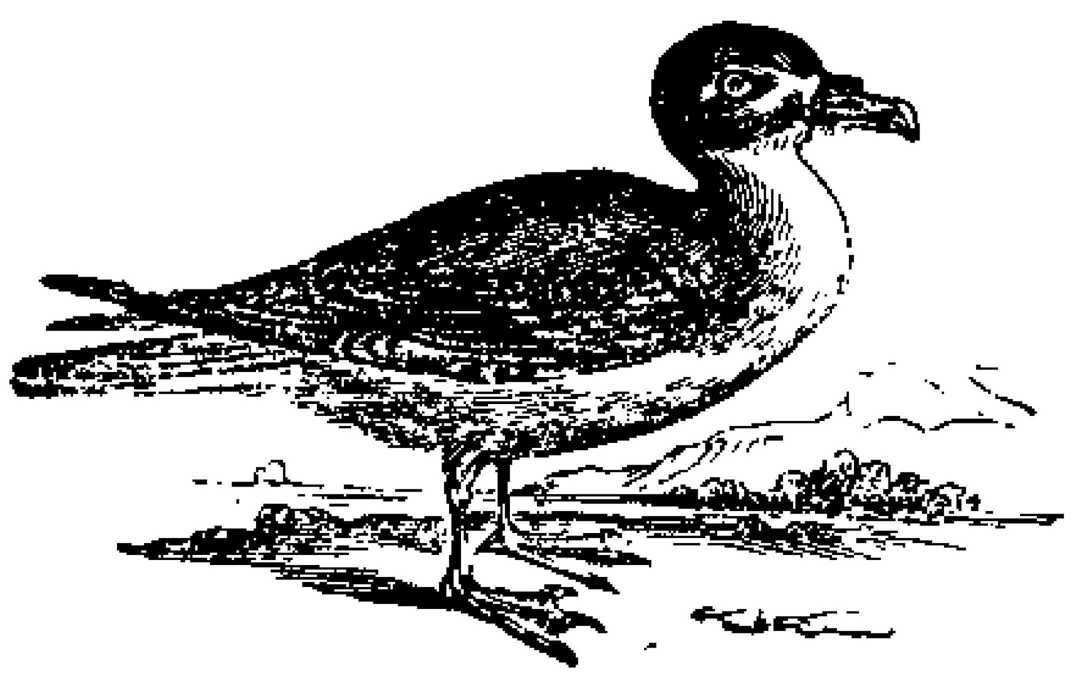
In the same "bird-city," but apart from the former, breed also the Common Gull (*Larus canus*) which is much smaller and of a more slender shape, and also the Sandwich and Caspian Terns. It is astonishing to see how each kind of sea-bird seeks its particular spot for breeding; only the auks and guillemots herd promiscuously. What may induce the birds to meet in such large bodies and then always to choose some particular cliff? The gulls yield the fortunate possessor of their district an annual income of at least two hundred rix-dollars. More than thirty thousand of the eggs, which are larger than those of the turkey, are collected every year, packed up with moss in baskets, and sent to the market. Two or three persons are busy from morning till evening, during the whole season, collecting the eggs, and receive for their trouble those of the smaller birds, which may also amount to about twenty thousand. But although the terns appear in considerable numbers on Sylt, they have chosen the small flat island, Norder Oog, to the west of Pelworm, for their chief residence. The breeding colony of the Sandwich tern amounts here to at least a million of individuals, so that when the birds are at rest, the island, at the distance of a mile, resembles a white stripe in the sea; but when their innumerable multitudes hover above it, they seem an immense white rotatory cloud. The eggs lie in some places so close together, that it is almost impossible to walk between them without treading upon them; the breeding birds often touch one another, and would not find room, if, like all sea-swallows that breed socially on the coast, they did not sit in the same posture, with their head facing the water. It is incomprehensible how each bird can find its eggs; it would even seem impossible, did we not know the miracles of animal instinct. Their noise is incessant, for even during the night they keep up a continual and lively prattle. He who approaches them during the day is soon surrounded by these screamers, whose whirling thousand-tongued multitudes stun his senses; and these birds, at other times so shy, flutter so close over his head, as often to touch him with their wings.

On Nowaja Semlja's ice-bound coast, on the peaks of isolated cliffs, and suffering no other bird in his vicinity, dwells the fierce imperious Burgomaster (*Larus glaucus*). None of its class dares dispute the authority of the lordly bird, when with un-

hesitating superiority it descends on its prey, though in the possession of another. Although not numerous, yet it is the general attendant on the whale-fisher whenever spoils are to be obtained. Then it hovers over the scene of action, and having marked out its morsel, descends upon it and carries it off on the wing. On its descent, the most dainty pieces must be relinquished, though in the grasp of fulmar, snow-bird, or kittiwake.

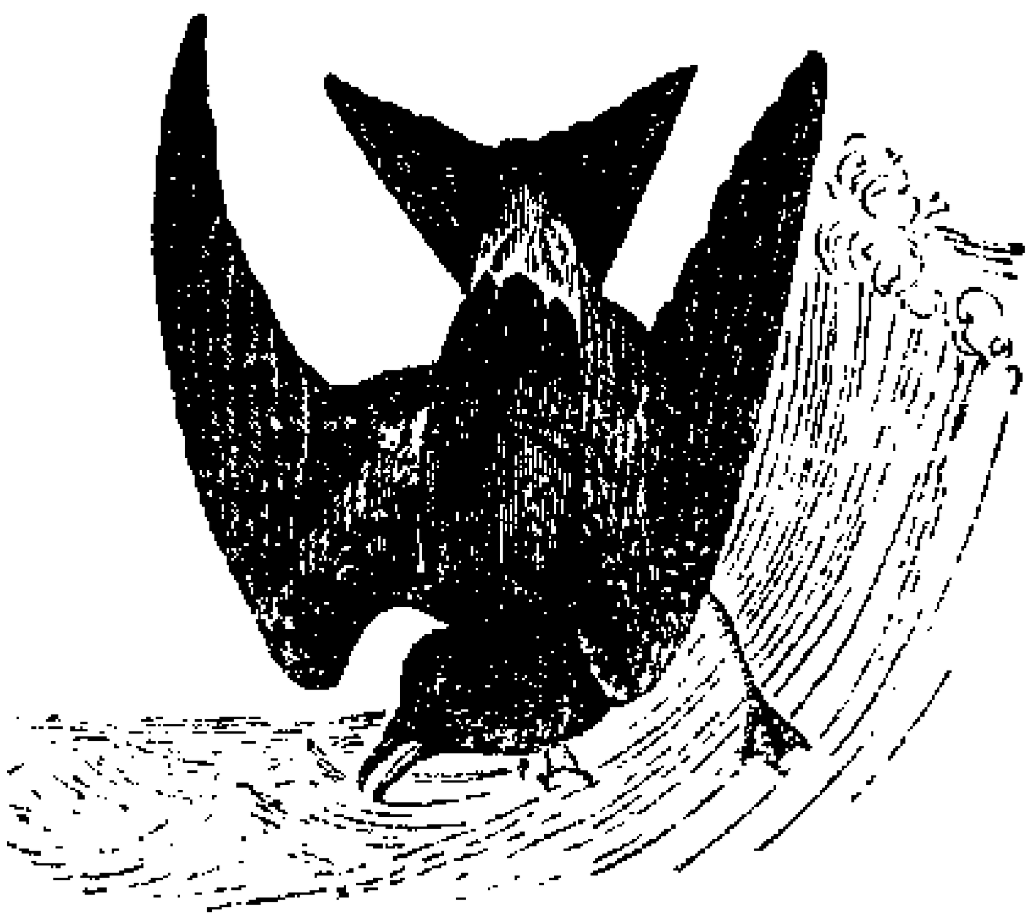
The larger parasitical or raptorial gulls (*Lestris parasiticus, catarrhactes*), are incapable of diving or plunging, their feathers being too large in proportion to their bulk. They are therefore obliged to live by the exertions of the lesser species, making them disgorge what they have eaten, and dexterously catching the rejected fish before it reaches the water. Thus we see the old feudal relations of baron and serf established as a natural institution among the gull-tribe.

Although the sea-swallows and sea-mews are endowed with great power of wing, yet the petrels and albatrosses alone deserve the name of oceanic birds, as they are almost always found on the high seas, at every distance from land, and only during breeding-time seek the solitary coasts and islands. Petrels are scattered over the whole extent of the ocean, but the petrels which inhabit the northern seas are different from those of the antarctic ocean, and between both are other species, that never forsake the intertropical waters.



Broad-billed Petrel.

The Fulmar (*Procellaria glacialis*) is at home in the high north. As soon as the whale-fisher has passed the Shetland Islands, on his way to the Arctic Seas, this bird is sure to accompany his track, eagerly watching for anything thrown overboard. Walking awkwardly on land, the fulmar flies to windward in the most terrific storms. Many thousands frequently accumulate round a dead whale, rushing in from all



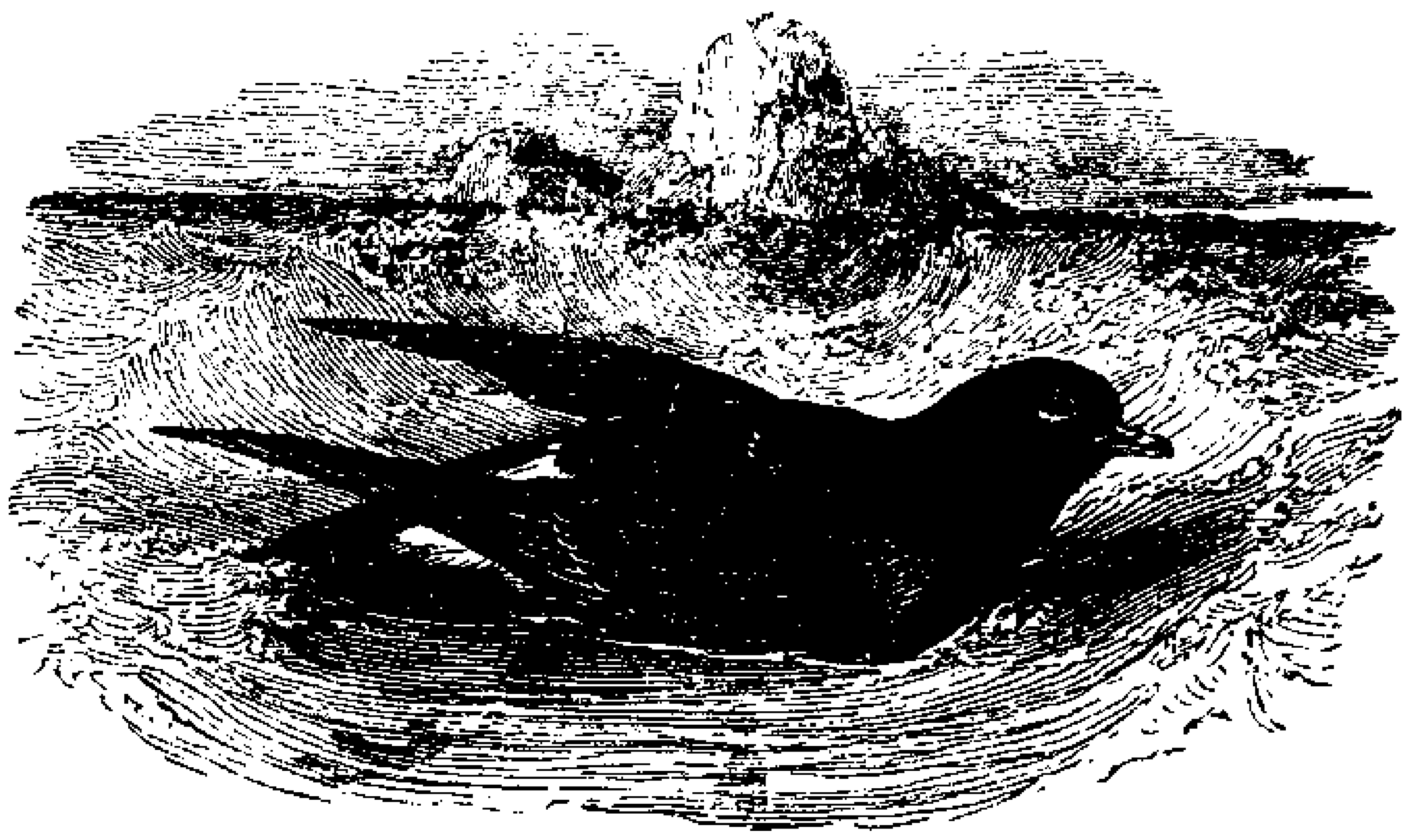
Fork-tailed Petrel.

quarters. The sea immediately about the ship's stern, when the men are engaged in skinning their gigantic prey, is sometimes so completely covered with them that a stone can scarcely be thrown overboard without striking one of them. When anything is thus cast among the crowd, those nearest take alarm, and so on, till a thousand are put in motion; but as in rising they strike the water with their feet, a loud and most irregular splashing is produced. It is amusing to observe with what jealousy they view, and with what boldness they attack, any of their species engaged in devouring the finest morsels, and to hear the curious chuckling noise they make in their anxiety for despatch, lest they should be disturbed. The voracious birds are frequently so glutted as to be unable to fly, in which case they rest upon the water until the advancement of digestion restores their wonted powers. They then return to the banquet with the same gusto as before, and although numbers of the species may have been killed with boat-hooks, and float among them, the others, nothing daunted, and unconscious of danger to themselves, continue their gormandising labours. When carrion is scarce, the fulmars follow the living whale, as if they had a presentiment of his future fate, and sometimes, by their peculiar motions while hovering on the surface of the water, point out to the fisherman the position of the animal. As their beak cannot make an impression on the dead whale until some more powerful creature tears away the skin, it may be imagined how delighted they are when man takes upon himself the trouble of peeling a whale for them.

The Glacial Petrel (*Procellaria gelida*) does not seem to approach the pole so near as the fulmar. He appears but seldom in Iceland, but breeds frequently in Newfoundland. The same is the case with the Shearwater (*P. puffinus*), which breeds in great numbers on the Feroë islands, and in Orcadia. The tropical petrels are the least known. They do not appear to gather troopwise, and but seldom follow ships. Towards 45° S. lat. the first Pintados (*P. capensis*) make their appearance, and are more rarely seen after having passed 60° S. lat. The Giant Petrel (*P. gigantea*), extends its flight as far as the ice-banks of the south, where the Antarctic and the Snowy (*P. antarctica et nivea*) Petrels first appear, birds which never leave those dreary seas, and are often seen in vast flocks floating

upon the drift ice. Thus nature has set bounds to petrels, as to all other creatures that swim or fly in and over the ocean, and has divided the wide deserts of the sea among their different species. Who can tell us the mysterious laws which assign to each of them its limits? Who can show us the invisible barriers they are not allowed to pass?

The Stormy Petrel (*P. pelagica*) seems to belong to every sea. It is about the size of a swallow, and in its general ap-



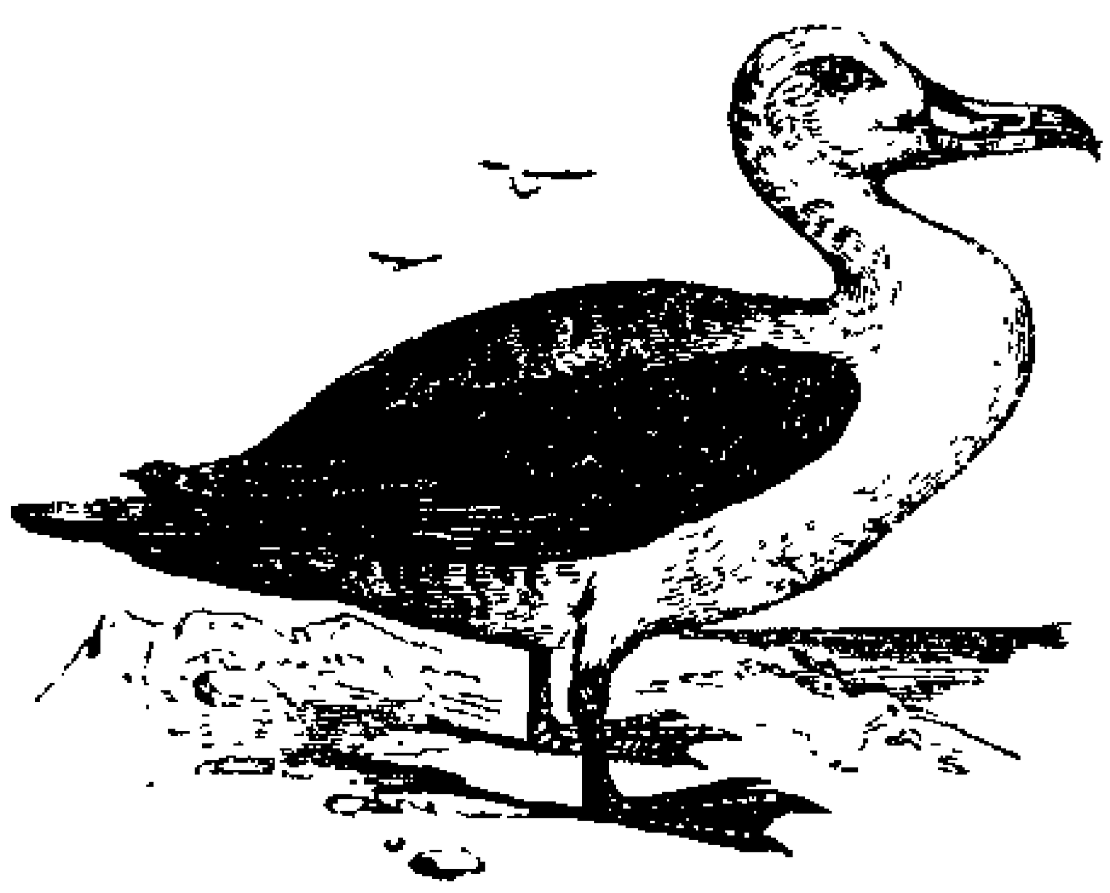
Stormy Petrel.

pearance and flight is not unlike that bird. Although the smallest web-footed bird known, it braves the utmost fury of the tempest, often skimming with incredible velocity the trough of the waves, and sometimes gliding rapidly over their snowy crests. Like all of its kind, it lives almost constantly at sea, and seeks during the breeding season some lonely rock, where it deposits in some fissure or crevice its solitary egg.

The mode of life of the petrels corresponds but little with their external beauty; they are in fact the crows of the ocean, and live upon the dead animal substances floating on its surface. Wherever the carcase of a whale, borne along by the current, covers the sea with a long stripe of putrid oil, they are seen feasting in the polluted waters. All petrels have the remarkable faculty of spouting oil of a very offensive smell, from their nostrils when alarmed, and this apparently as a means of defence.

The Albatross (*Diomedea exulans*) is the monarch of the high seas; the picture of a hero, who, under every storm of adverse fortune, preserves the immoveable constancy of an undaunted heart. Proud and majestic, he swims along in his own native

element, and without ever touching the water with his pinions, rises with the rising billow, and falls with the falling wave. It is truly wonderful how he bids defiance to the fury of the unshackled elements, and how quietly he faces the gale. "He seems quite at home," say the sailors; and indeed this expression is perfectly characteristic of his graceful ease as he hovers over the agitated ocean.



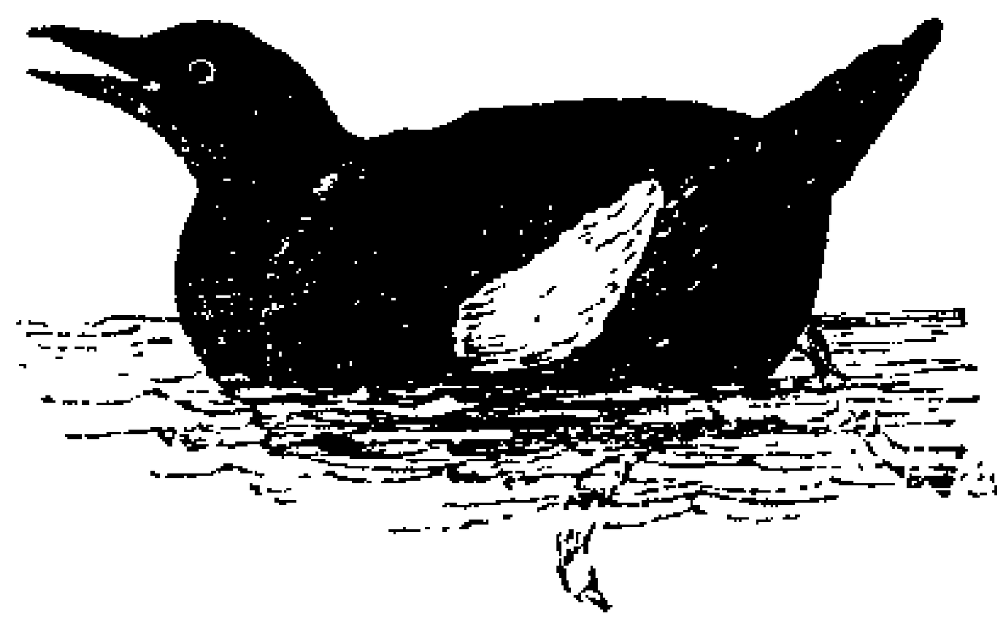
Wandering Albatross.

The albatross exceeds the swan in size, attains a weight of from 12lbs. to 28lbs., and extends his wings from ten to thirteen feet. His plumage is white and black, harmonising with the wave-crest and the storm-cloud. For weeks and months together he is seen to follow the course of a ship; but, according to Mr. Harvey (Sea Side Book), "the time he can remain on the wing seems to have been much exaggerated, for although, like the gull and the petrel, he is no diving-bird, he swims with the greatest ease; and notwithstanding the enormous length of his pinions, knows well how to rise again into the air. He is indeed unable to take wing from a narrow deck, but when he wishes to rise from the sea, he runs along flapping the waters until he has acquired the necessary impetus, or meets with a wave of a sufficient height, from whose lofty crest he starts as from a rocky pinnacle, and resumes his extensive flight over an immense expanse of ocean." A short-winged species frequents the waters of Kamtschatka and Japan; but the *wandering* albatross (*D. exulans*) belongs more particularly to the southern hemisphere, being rarely seen to the north of 30° S. lat., and appearing more frequently as the higher latitudes are approached. The regions of storms — the Cape of Good Hope and Cape Horn—are his favourite resorts, and all travellers know that the southern point of Africa is not far distant as soon as the albatrosses show themselves in larger numbers. These birds are the vultures of the ocean; their crooked sharp-edged beak is better adapted to lacerate a lifeless prey, than to seize upon the rapid fish as it darts swiftly along below the surface of the waters. From a vast distance they smell the floating carcase of a whale, and soon alight in considerable numbers upon the

giant carrion. They also feed upon the large cephalopods that inhabit mid-ocean, and remains of these molluscs are generally found in their stomach. The Auckland and Campbell islands seem to be two of their favourite breeding-stations. When Sir James Ross visited these secluded groups, the birds were so assiduously breeding as to allow themselves to be taken with the hand. The nest is built of sand mixed with dried leaves and grasses, generally eighteen inches high, with a diameter of twenty-seven inches at the surface, and of six feet at the base. While breeding, the snow-white head and neck of the bird project above the grasses, and betray it from afar. On endeavouring to drive it from its eggs it defends itself valiantly, snapping with its beak. Its greatest enemy is a fierce raptorial gull (*Lestris antarcticus*), which is always on the look-out, and, as soon as the albatross leaves the nest, shoots down upon it to steal the eggs.

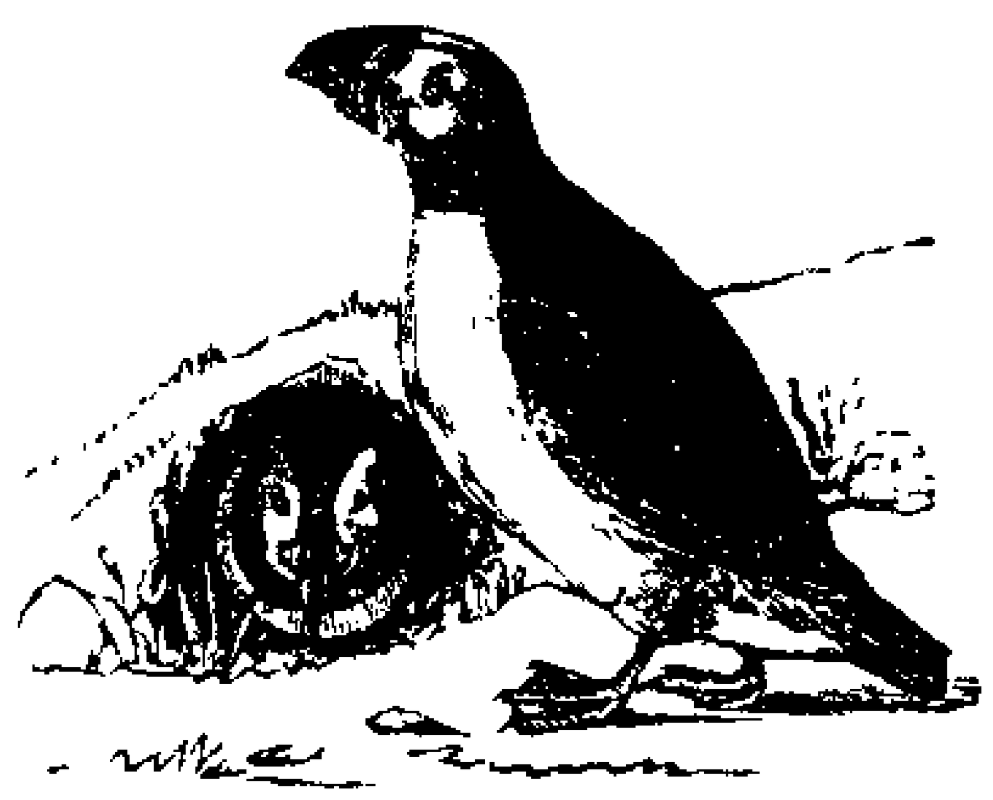
Swift flies the albatross, but fancy travels with still more rapid wings through the realms of space, and leads us suddenly from the lone islands of the Pacific to the north of another hemisphere. Saint Kilda rises before us —a glorious sight when the last rays of the setting sun, as he slowly sinks upon the ocean, light up with dazzling splendour the towering cliffs of the island, which one might almost fancy to be some huge volcano newly emerged from the deep, or the impregnable bulwark of some enchanted land. St. Kilda, one of the most striking examples of the grandest rock-scenery, plunges on all sides perpendicularly into the sea, so that although six miles in circumference, it affords but one single landing-place, accessible only in fair weather. Four of the promontories are perforated, and as many large caverns are formed, through which the sea rolls its heaving billows. From the eastern extremity, which rises nearly perpendicularly to the height of 1380 feet, and is supposed to be the loftiest precipice in Britain, the view is of indescribable sublimity. Far below, the long heavy swell of the ocean is seen climbing up the dark rock, whose base is clothed with sheets of snow-white foam. In many places the naked rock disappears under the myriads of sea-birds sitting upon their nests; the air is literally clouded with them, and the water seems profusely dotted with the larger fowl, the smaller ones being nearly invisible on account of the distance. Every narrow ledge is thickly covered

with kittiwakes, auks, and guillemots; all the grassy spots are tenanted by the fulmar, and honey-combed by myriads of puffins; while close to the water's edge on the wet rocks, which are hollowed out into deep recesses, sit clusters of cormorants, erect and motionless, like so many unclean spirits, guarding the entrance of some gloomy cave.



Black Guillemot.

On rolling down a large stone from the summit, a strange scene of confusion ensues. Here, falling like a thunderbolt on some unfortunate fulmar sitting upon its nest, it crushes the poor creature in an instant; then rolling down the crags, and cutting deep furrows in the grassy slopes, it scatters in dismay the dense groups of auks and guillemots. Its progress all along is marked by the clouds of birds, which affrighted shoot out from the precipice to avoid the fate to which nevertheless many fall a prey, until at length it reaches the bottom along with its many victims. The scared tenants of the rock now return to their resting-places, and all is again comparatively quiet.



Common Puffin.

Several species of gulls are of common occurrence on St. Kilda: *Larus marinus, fuscus, canus,* and *tridactylus.* The last, or kittiwake, is the most abundant; a social bird, choosing the most inaccessible spots. On disturbing a colony of kittiwakes, most of the birds leave their nests and fly about the intruder, uttering incessantly their clamorous but not unmusical cry. The noise from a large flock is almost deafening; the flapping of their wings and their loud screams, joined to the deep guttural notes of the passing gannets, and the shrill tones of the larger gulls, form a combination of sounds without a parallel in nature. Probably on account of its vigilance, the kittiwake is not pursued by the fowler.

The fulmar breeds in almost incredible numbers on St. Kilda (the only place in Britain where he is found), and is to the natives by far the most important production of their barren

land. On the crest of the highest precipices, and only on such as are furnished with small grassy shelves, on every spot above a few inches in extent, the fulmars have taken possession of the rock. On being seized, they instantly disgorge a quantity of clear amber-coloured oil, which imparts to the whole bird, its nest and young, and even the very rock which it frequents, a peculiar and very disagreeable odour.

Fulmar oil is one of the most valuable productions of St. Kilda. The best is obtained from the old bird by surprising it at night upon the rock, and tightly closing the bill until the fowler has seized the bird between his knees with its head downwards. By opening the bill, the fulmar is allowed to eject about a table-spoonful, or rather more, of oil into the dried gullet or stomach of a solan-goose. The islanders use fulmar-oil for their lamps, and consider it as an infallible remedy against chronic rheumatism.

It is chiefly in pursuit of the fulmar that the St. Kildian often endangers his life. Two of the fowlers generally proceed in company, each furnished with several coils of rope, about half an inch in diameter. One of them fastens one of the ropes under his armpits, and holding the extremity of another rope in one hand, is lowered down the cliff. His comrade stands a little away from the edge, holding the supporting rope firmly with both hands and letting it out very slowly, while he allows the other, or guide-rope, to slip out as is required from under one foot, which loosely secures it. On reaching a ledge occupied by birds, the fowler commences his operations, easily securing the eggs and young birds, and knocking down the old ones with a short stick, or catching them by a noose attached to a long slender rod. He then secures his sport by bundling the birds together, and tying them to a rope let down from above, depositing at the same time in a small basket the eggs he has gathered. The dexterity of these rocksmen is truly astonishing. The smallest spot is considered by them as a sufficiently secure standing-place, and they will creep on hands and knees, though cumbered with a load of birds, along a narrow ledge, seemingly without concern for their personal safety. When exhibiting before strangers, a precipice about six hundred feet high, overhanging the sea, at a short distance from the village, is generally chosen for a display of their agility. About midway they strike against the

rock, and rebound twelve feet or more with all the agility of a tight-rope dancer.

The Gannet, or Solan-goose, which abounds in the north of Scotland and on the numberless islands and rocky fiords which line the Norwegian coast, likewise congregates in vast numbers about St. Kilda, from whence a portion of them take their departure every morning to fish for herrings, their favourite food, in the bays and channels of the other Hebrides, the nearest of which is about fifty miles distant. This bird is very select in the choice of its breeding-places, which it occupies to the total exclusion of every other species. None are to be found in Hirta, but the island of Borreray is almost entirely occupied with them, as are also the adjacent rocks, Stack Ly and Stack Narmin.

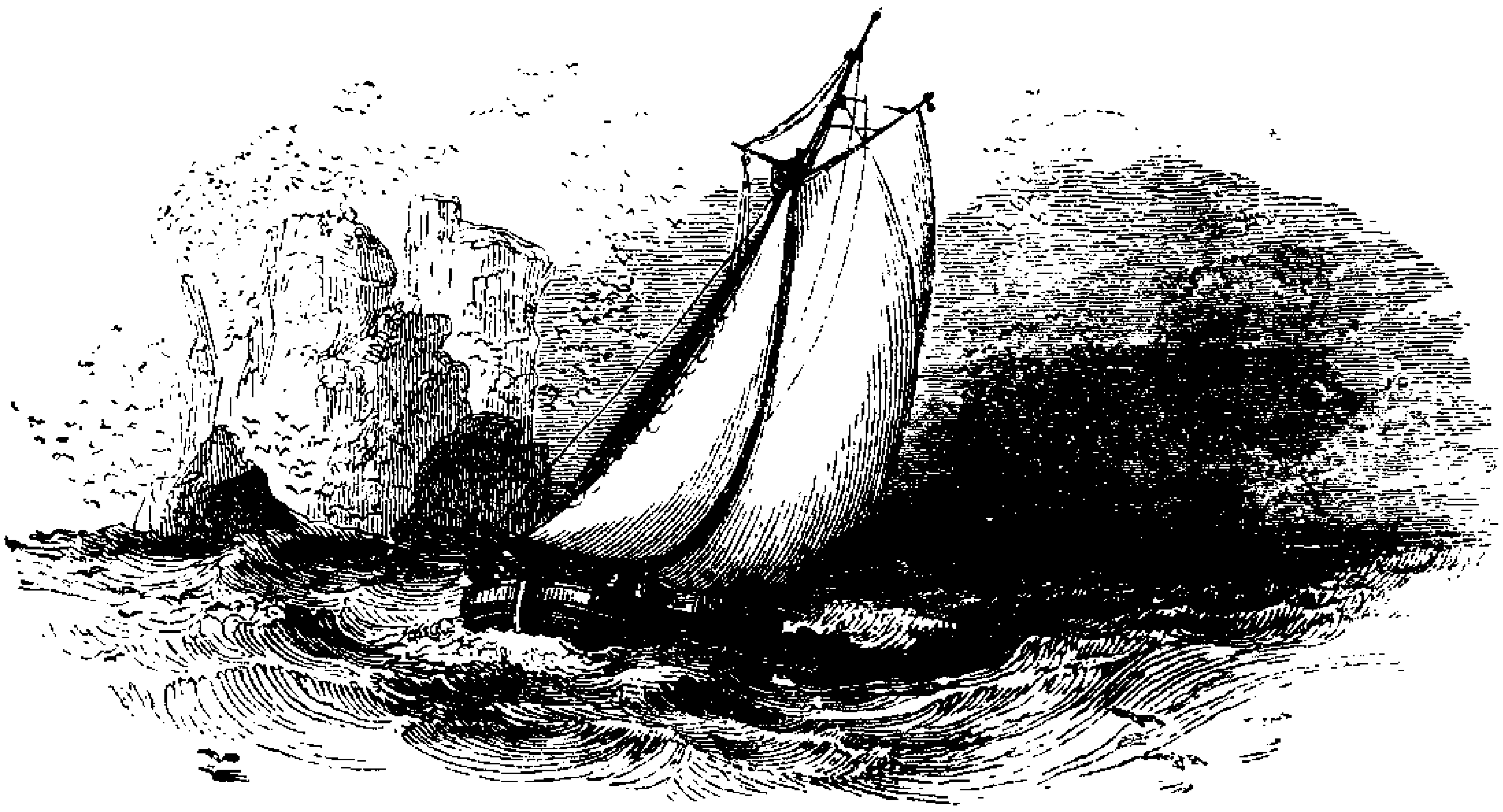
Puffin.

These cliffs are remarkable for their pointed summits and towering height, and appear, even from the distance of many miles, as if they were covered with snow, the deceptive appearance being caused by the myriads of gannets with which the rock is thickly covered, as well as the dense clouds of these white-plumed birds passing and repassing in the neighbourhood of their nests. Petrels, shearwaters, puffins, guillemots, and auks, are also very abundant about the weather-beaten cliffs of St. Kilda.

If we consider that similar bird-republics are to be found on almost every rocky coast or surf-beaten cliff of the northern seas, we must needs be astonished at the inexhaustible prodi-

gality of Nature, which covers desolate rocks with such a profusion of life. The vast number of sea-birds is the more surprising, as many species, such as the guillemot, the auk, the fulmar, and the puffin, lay but one single egg on the naked rock, and often in so precarious a situation, that it is almost inconceivable how breeding can take place. When the birds are surprised and suddenly fly off, many of the eggs tumble down into the surf. Sea-eagles, falcons, and raptorial gulls destroy a great number, and pounce upon the young; thousands fall a prey to the rigours of an Arctic winter; the spring-tides sweeping over low shores, often carry away whole generations at once, and many a maritime population lives entirely upon the sea-fowl that breed upon the sterile soil. And yet, in spite of so many enemies and persecutions, their numbers remain undiminished, nor has their importance ever ceased in the domestic economy of the rude islanders of the north.

Auk.


Sea-Fowl Shooting.

But however valuable the eggs and the oil, the feathers and the flesh of the hyperborean bird-republics may be to man, they are far from equalling in importance the guano-producing sea-fowl of the tropical seas. This inestimable manure, which has become so indispensable to the British agriculturist, is found scattered

over numerous localities in the intertropical regions. It abounds on many of the rocky islets of the Red Sea, where the life-teeming waters afford sustenance to innumerable sea-gulls, cormorants, and pelicans; but its most widely celebrated stores cover the small Chincha Islands, not far from Pisco, about a hundred miles to the south of Callao, where they form enormous layers 50 or 60 feet deep.

The upper strata are of a greyish-brown colour, which lower down becomes darker; and in the inferior strata the colour is a rusty red, as if tinged by oxide of iron. The guano becomes progressively more and more compact from the surface downwards, a circumstance naturally accounted for by the gradual deposit of the strata and the increasing superincumbent weight. As is universally known, guano is formed of the excrements of different kinds of marine birds; but the species which Tschudi, the celebrated Peruvian traveller, more particularly enumerates are—*Larus modestus* (Tschudi), *Rhynchops nigra* (Linn.), *Plotus anhinga* (Linn.), *Pelecanus thayus* (Mol.), *Phalacrocorax Gaimardii* and *albigula* (Tsch.), and chiefly the *Sula variegata* (Tsch.).

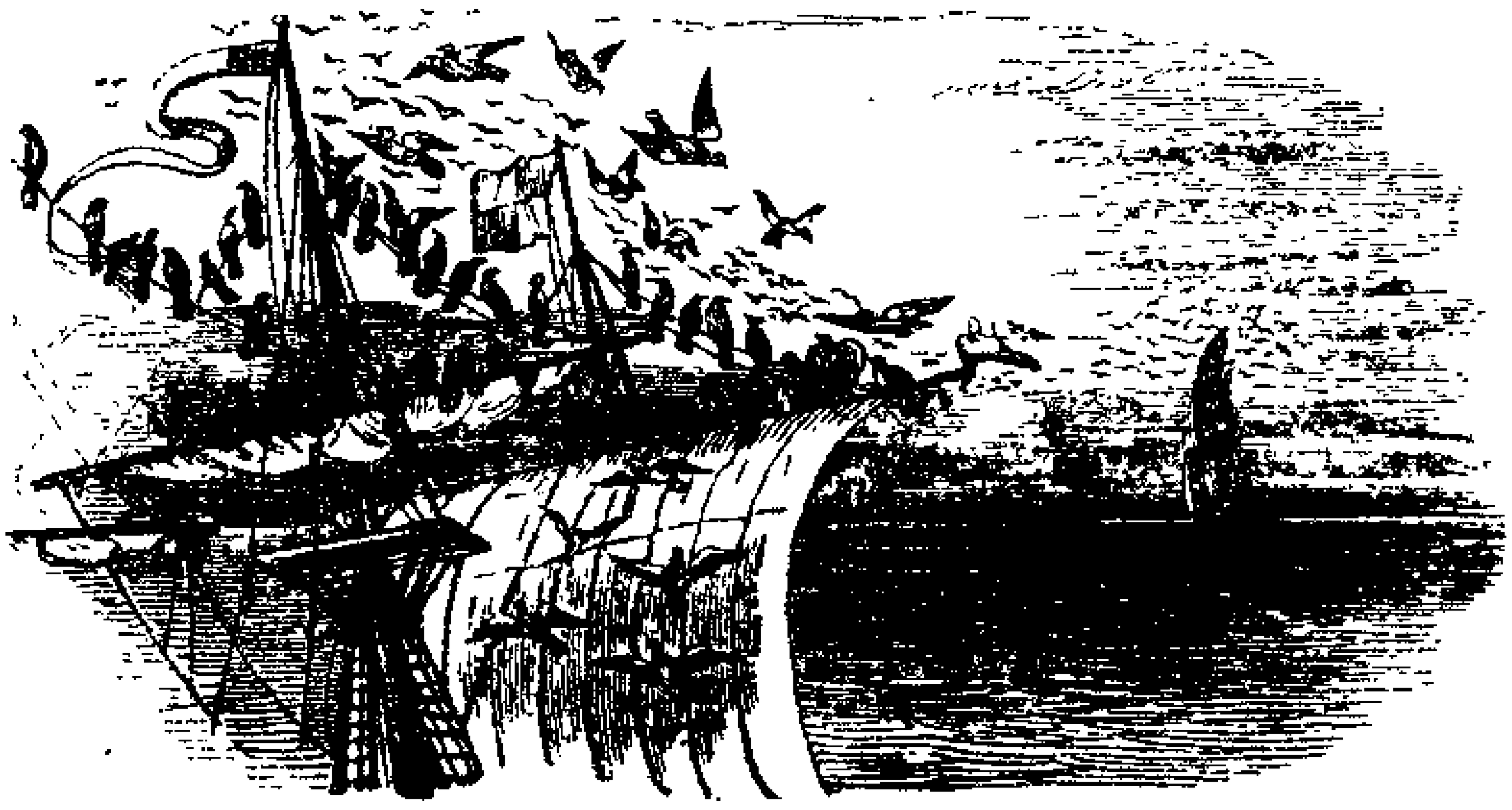
The immense flocks of these birds, as they fly along the coast, appear like aërial islands; and when their vast numbers, their extraordinary voracity, and the facility with which they procure their food are considered, we cannot be surprised at the magnitude of the beds of guano which have resulted from the uninterrupted accumulations of countless ages. During the first year of the deposit the strata are white, and the guano is then called *Guano blanco.* In the opinion of the Peruvian cultivators, this is the most efficacious kind. As soon as the dealers in guano begin to work one of the beds, the island on which it is formed is abandoned by the birds. It has also been remarked that, since the increase of trade and navigation, they have withdrawn from the islands in the neighbourhood of the ports. Under the empire of the Incas, the guano was regarded as an important branch of state economy. It was forbidden, on pain of death, to kill the young birds. Each island had its own inspector, and was assigned to a certain province. The whole distance between Arica and Chaucay, a length of two hundred nautical miles, was exclusively manured with guano. These wise provisions have been entirely forgotten by the Spaniards, but the Peruvians now begin to discover the error of their former masters, and look

forward with anxiety to the period when the guano will no longer suffice for the wants of husbandry. At the present day they use it chiefly in the cultivation of maize and potatoes. A few weeks after the seeds begin to shoot, a little hole is made round each root and filled up with guano, which is afterwards covered with a layer of earth. After the lapse of twelve or fifteen hours, the whole field is laid under water, and left in that state for about half a day. Of the guano blanco a less quantity suffices, and the field must be more speedily and abundantly watered, otherwise the roots would be destroyed. The effect of this manure is incredibly rapid. In a few days the growth of the plant is doubled; if the manure is repeated a second time, but in smaller quantity, a rich harvest is certain;—at least the produce will be three times greater than that which would have been obtained from the unmanured soil. The uniformity of climate, along a coast where rain is *never* known to fall, contributes essentially to the superior quality of the Chincha guano, as atmospherical precipitations naturally dissolve and wash away many of the most fertilising salts.

The consumption of guano in Western Europe, and particularly in England, increases with surprising rapidity. On the island of Iquique a layer thirty feet deep, and covering a space of 220,000 square feet, has been entirely removed within twenty-seven years. In the year 1854, 250,000 tons were dug in the Chincha Islands, and the actual annual exportation amounts to double the quantity. The digestive functions of the Sula and her companions thus bring in *larger* sums to the Peruvian Government than all the silver mines of Cerro de Pasco, and the transport of the guano employs larger fleets than ever Spain possessed at the brightest period of her power.

"The Chincha Islands," says Castelnau (*Expédition dans les Parties Centrales de l'Amérique du Sud;* Paris, 1851), "are completely desert and devoid of vegetation; their granite soil is clearly distinguished by its colour from the thick stratum of guano with which it is covered, and the surface of which looks at a distance like snow. The steep banks render landing difficult, but facilitate at the same time the shipping of the produce, as the vessels lie at anchor close to the pits. Digging takes place at three places, close to one another, and the traveller has only to compare the enormous deposits with

the smallness of the excavations, which at some distance are hardly perceptible, to convince himself of the inexhaustible supply. Some huts have been constructed on the island, where, in the midst of ammoniacal effluvia, some Peruvian custom-house officers and soldiers superintend the working of the guano-mines."



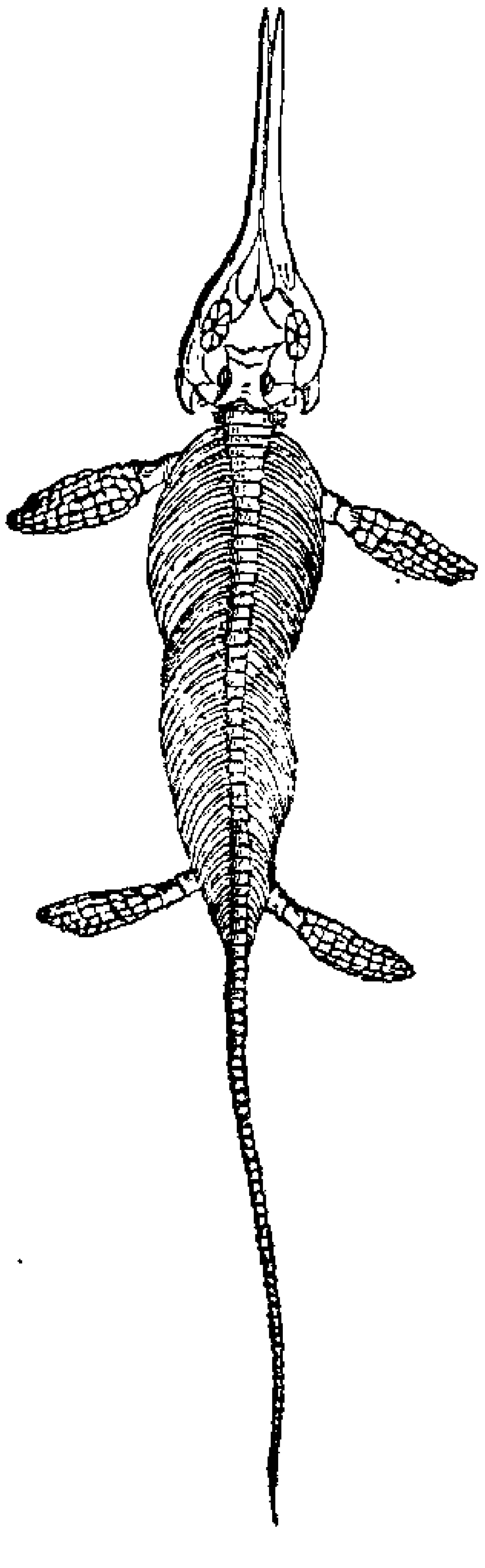
Birds of Passage

CHAP. XI.

THE REPTILES OF THE OCEAN.

The Saurians of the Past Seas.—The Anatomical Structure of the Turtles—Their Size—Their Visits to the Shores—The Dangers that await their Young—Turtles on the Brazilian Coast—Prince Maximilian of Neuwied and the Turtle—Conflicts of the Turtles with Wild Dogs and Tigers on the Coast of Java—Turtle-catching on Ascension Island—Tortoise-shell—The Amblyrhynchus cristatus—Marine Snakes—The Great Sea-Snake.

THERE was a time when the reptiles were the monarchs of the sea, when the ocean swarmed with gigantic saurians, tyrants of the fishes, combining the swiftness of the dolphin with the rapacity of the crocodile. Had those monsters of the deep been endowed with human intelligence, they would most likely also, with human arrogance, have boasted of an eternal sway. For where in the whole ocean was the enemy that could cope with them? Did not all beings flee wherever they appeared? and did not the inexhaustible sea promise them an everlasting supply of food?



Ichthyosaurus.

But in spite of their colossal power, the saurians, like all created beings, have been forced to succumb to time.

Centuries and centuries passed on, the sea and air gradually changed, the temperature of the elements no longer remained the same, and thus by degrees a new ocean and a new atmosphere were formed, uncongenial to the nature of those huge reptiles. Thus they have been effaced from the roll of living things, and some petrified remains alone bear testimony to their former existence.

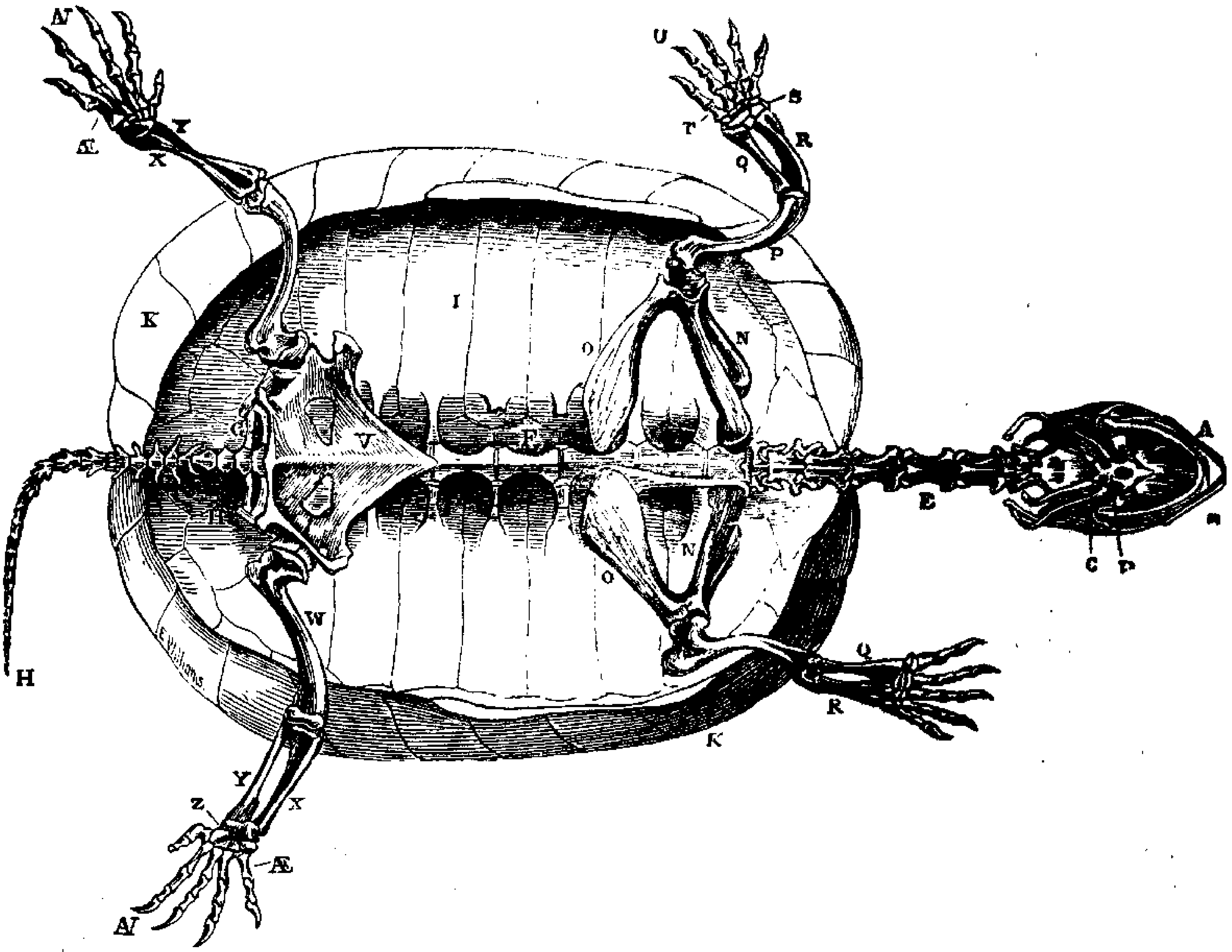
The most powerful saurians of the present day—the crocodile

the gavial and the alligator—have left to the dolphins, the sharks, and other monstrous or swiftly-swimming cetaceans and fishes the dominion of the seas, and now merely infest the rivers and swamps of the tropical zone. The lizards also have long since retired from the scene where they once abounded, and the ocean at present harbours no other reptiles in its bosom than turtles and sea-snakes.

Most of the animals belonging to this class are either dangerous or of a disgusting appearance. Few creatures are objects of such universal abhorrence as the crocodile—the very type of brutal cold-blooded ferocity; as the venomous snake—the emblem of perfidy and ingratitude; or as the loathsome, but innocent toad, to which, on account of its ugliness, noxious properties have been ascribed which the poor animal does not possess. The frogs, lizards, and turtles alone seem to have escaped this general detestation, either from their more active habits, or their well-known harmlessness, or their various utility to man.

The anatomy of the turtle offers many points of interest; its vertebræ, ribs, and breast-bone growing together so as to form a bony envelope round the whole animal. This harness is covered by the skin, which in its turn is bedecked with large scales, while all the muscles and other soft parts are enclosed in the inner cavity. Only the head, feet, and tail protrude through openings between the upper and under carapace, and these can, by the land tortoises at least, be withdrawn entirely under the former. This is the only protection which Nature has afforded these animals against their enemies, for they have neither swiftness of flight, nor any offensive weapon at their command. But as soon as anything suspicious approaches, they conceal themselves under their massive cover, and oppose to every attack by tooth or nail the passive resistance of an impenetrable shield. Most of their enemies find it, besides, no easy task to turn them on their back, as many species attain a very considerable weight, so that their mere bulk constitutes a good defence. It might be supposed that this protection could only avail for a short time, as the want of air must soon force the animal to stretch its head out of its hiding-place, and this indeed would be the case, if kind Nature had not taken her measures against this emergency, by giving the creature a *cold* blood, so that it can remain a very

long time without breathing; long enough, at least, to tire the patience of the most obstinate foe.



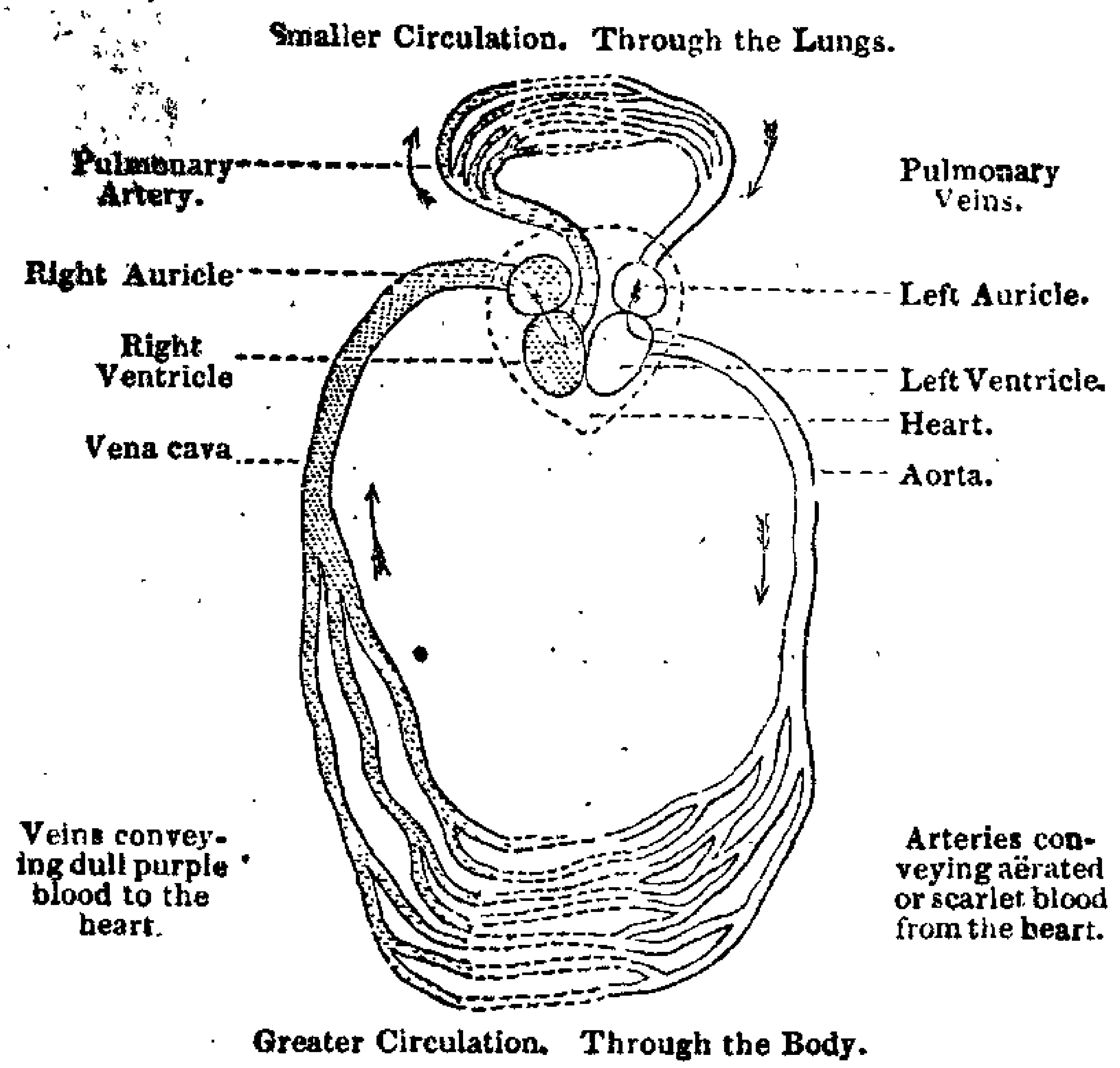
Skeleton of Tortoise.

A, superior maxilla; B, inferior maxilla; C, ossiculum auditus; D, os hyoides: E, cervical vertebræ; F, dorsal vertebræ; G, sacrum; H, caudal vertebræ; I, dorsal ribs; K, marginal scales; N, scapula; O, coracoid bone; P, os humeri; Q, radius; R, ulna; S, bones of the carpus; T, metacarpal bones; U, digital phalanges; V, pelvis; W, femur; X, tibia; Y, fibula; Z, tarsus; Æ, metatarsus; A.V., phalanges of the foot.

But how comes it, the reader may ask, that respiration, which pours a warm current through our veins, fails in raising the temperature of the turtle's blood?

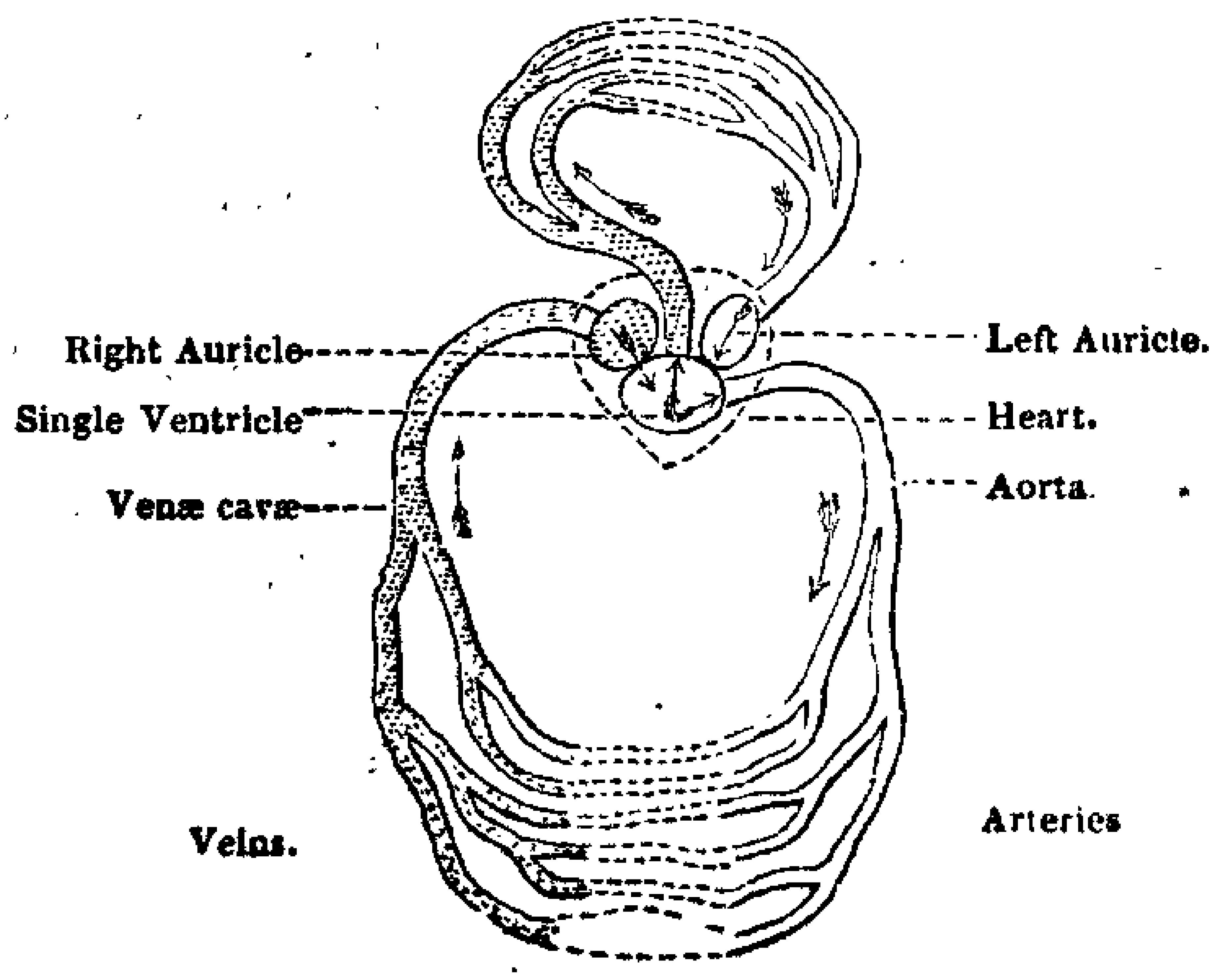
Without entering into a lengthened description of the human heart, I shall merely observe that it consists of two halves (each half being again subdivided into two separate chambers), and that the right half, which receives venous blood and pours it into the lungs, is completely separated by a partition from the left half, which receives arterial or aërated blood from the lungs, and propels it into every part of the body. Thus the two different kinds of blood are completely separated, so that an *unmixed* venous blood flows into the lungs, where it is converted by the oxygen of the air into arterial blood. But this connection, like most chemical processes, takes place under an evolution of

heat, which is so considerable that our internal temperature constantly maintains itself at the height of 98° F.



Theoretic Representation of the Circulation in Mammals and Birds.

But the turtle's heart is differently formed, consisting, as the annexed theoretic representation shows, of but one ventricle and two auricles, so that a *mixed*, or only half aërated blood circulates



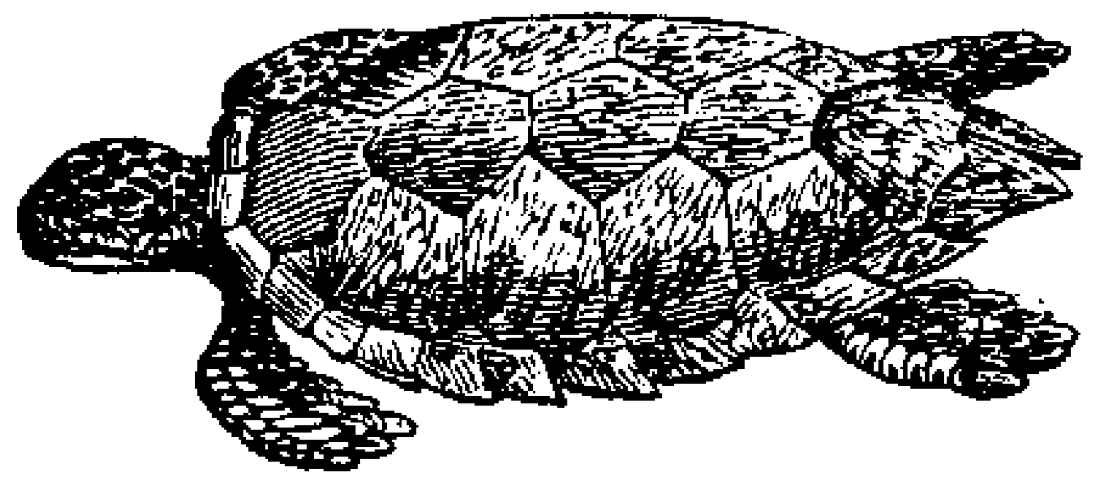
Theoretic Representation of the Circulation in Reptiles.

throughout the body, which naturally produces a torpidity of the whole vital process. Besides, the lungs of the reptiles are inca-

pable of aërating so great a quantity of blood as ours, as their cells are much larger, thus offering less surface to the action of the air; and finally, the ribs of the turtles being immovable, they are incapable of extending the lungs, so that the animal is absolutely obliged to swallow the necessary supply of air, and to pump it, as it were, into the lungs, by contracting the muscles of the throat. Thus we see that every precaution has been taken to reduce respiration to a low standard, and prevent the evolution of heat. With this indolence of its cold-blooded circulation, the whole nature of the animal is in harmony; the bluntness of its senses, its want of intelligence, its slow movements, and its long endurance of hunger, thirst, and want of air. It leads but a drowsy dream-like existence, and yet, we may be sure, it is far from unhappy, for all its functions and organs agree perfectly one with the other, and when concord reigns, enjoyment of some kind must exist.

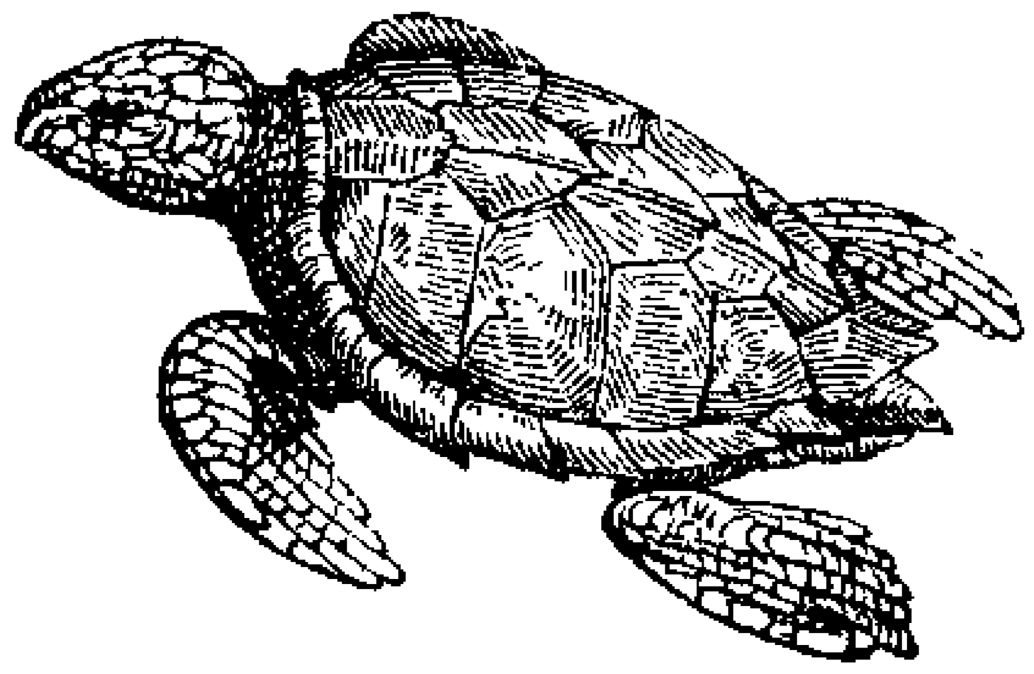
The turtles are distinguished from the land tortoises particularly by their large and long fin-shaped feet, and also by a longer tail, which serves them as a rudder. They have no teeth, but the horny upper jaw closes over the lower like the lid of a box, thus serving them as excellent shears, either for crushing shells or dividing the tough fibres of the sea-grass.

They are at home in all the warmer seas, but sometimes they are carried by oceanic streams far away from their accustomed haunts. Thus, in the year 1752, a Green turtle, six feet long, and weighing 900 pounds, stranded near Dieppe; and in 1778 another, seven feet long, on the coast of Languedoc. One taken on the coast of Cornwall in July, 1756, measured from the tip of the nose to the end of the shell, six feet nine inches, and the weight was supposed to be nearly 800 pounds. These few examples show us that the turtles rank among the larger inhabitants of the ocean, although they are far from attaining the fabulous proportions assigned to them by Pliny (who makes the Indians use their shells as boats or roofs), or the enormous size of some colossal extinct species, such as the fossil tortoise from the Siwala hills, preserved in the East Indian Museum, which measures twelve feet in length. They live almost constantly at sea, partly on shell-fish, like the fierce Loggerhead turtle



Green Turtle.

(*Testudo Caretta*), partly on sea-grass, like the Green turtle (*T. Midas*), and only go on shore during the warmest months of the year, for the purpose of laying their eggs.


Loggerhead Turtle.

"We followed the monotonous sea-coast," says Prince Maximilian of Neuwied, in his interesting "Travels through the Brazils;" "our two soldiers, a Negro and an Indian, frequently stopping to dig turtle-eggs out of the sand, which, boiled in sea-water, used to form our evening repast. Once, while they were busy gathering drift-wood for cooking, we found at a small distance from our fire an enormous turtle busy laying her eggs. We could not possibly have met with anything more agreeable; the creature seemed to have crawled there for the express purpose of providing for our supper. Our presence did not discompose her in the least; she allowed herself to be touched, and even raised from the ground, for which purpose four men were required. During our loud deliberations on her future fate, she gave no other sign of uneasiness than a blowing sound, and continued to work slowly with her hind fins, throwing up the earth at regular intervals.

One of the soldiers stretched himself out at full length on the ground near the purveyor of our kitchen, inserted his arm into the earth-hole, and threw out the eggs as they were laid by the turtle. In this manner above a hundred were collected in about ten minutes. A council was now held as to the means of adding the beast to our collection, but as it would have required an additional mule for the transport, we gave it its life. These colossal turtles—Midas, Coriacea, and Caretta—especially choose these desert coasts for the laying of their eggs. They emerge from the sea in the dusk of evening, and then crawl back again into the water one or two hours after the setting of the sun. Thus also the friendly turtle, which had so abundantly provided for our wants, disappeared after a short time; we found the large hole filled up, and a broad trace in the sand showed that the animal had again retreated to its favourite element. The Midas is said to lay from ten to twelve dozen, and the Coriacea from eighteen to twenty dozen eggs at once."

The wild sand coast of Bantam (Java) is annually frequented by a large number of turtles. They are often obliged to creep over nearly a quarter of a mile of the beach, before finding at the foot of the sand-dunes a dry and loose soil fit for their purpose; and on this journey, which for them is a very long one, they have many dangers to encounter. Hundreds of their skeletons lie scattered about the strand, many of them five feet long, and three feet broad; some bleached and cleaned by time, others still half filled with putrid intestines, and others, again, quite fresh and bleeding. High in the air a number of birds of prey wheel about, scared by the traveller's approach. Here is the place where the turtles are attacked by the wild dogs. In packs of from twenty to fifty, the growling rabble assails the poor sea-animal at every accessible point, gnaws and tugs at the feet and at the head, and succeeds by united efforts in turning the huge creature upon its back. Then the abdominal scales are torn off, and the ravenous dogs hold a bloody meal on the flesh, intestines, and eggs of their defenceless prey. Sometimes, however, the turtle escapes their rage, and dragging its lacerating tormentors along with it, succeeds in regaining the friendly sea. Nor do the dogs always enjoy an undisturbed repast. Often during the night, the "lord of the wilderness," the royal tiger, bursts out of the forest, pauses for a moment, casts a glance over the strand, approaches slowly, and then with one bound, accompanied by a terrific roar, springs among the dogs, scattering the howling band like chaff before the wind. And now it is the tiger's turn to feast, but even he, though rarely, is sometimes disturbed by man. Thus, on this lonely, melancholy coast, wild dogs and tigers wage an unequal war with the inhabitants of the ocean.

The cold-blooded turtle is obliged to confide the hatching of her eggs to the sun, which generally accomplishes the task in three weeks. On creeping out of the egg, the young, even those of the largest species, are not larger than half-a-crown and of a white colour. Unprotected by a parent's tenderness, the poor little creatures seem only to be born for immediate death. Their first instinctive movements are towards the element for which they are destined; slowly they drag themselves towards the water, but the sea meets them with a rough embrace, and the

unmerciful waves generally throw them back again upon the shore. Here they are attacked by great sea-birds, storks and herons, against which, in spite of their smallness, they make feeble efforts of defence, or by still more powerful beasts of prey; and thus the greater part of the unfortunate brood is destroyed at its very first entrance into life; while those which reach the sea, are generally devoured by sharks and other sharp-toothed fishes. It is therefore not in vain that the turtle lays four or five hundred eggs in the course of a single summer, for were she less fruitful, the race would long since have been extinguished.

I need hardly mention, that the flesh of the green turtle is everywhere esteemed as a first-rate delicacy. The king of the Manga Reva Islands in the South Sea keeps them in a pen for the wants of his table; and the London alderman is said to know no greater enjoyment than swallowing a basin of turtle-soup. Hence it is no wonder that the mariner, tired of salt-beef and dried peas, persecutes them on all the coasts of the tropical seas, wherever solitude, a flat beach, and a favourable season promise to reward his trouble.

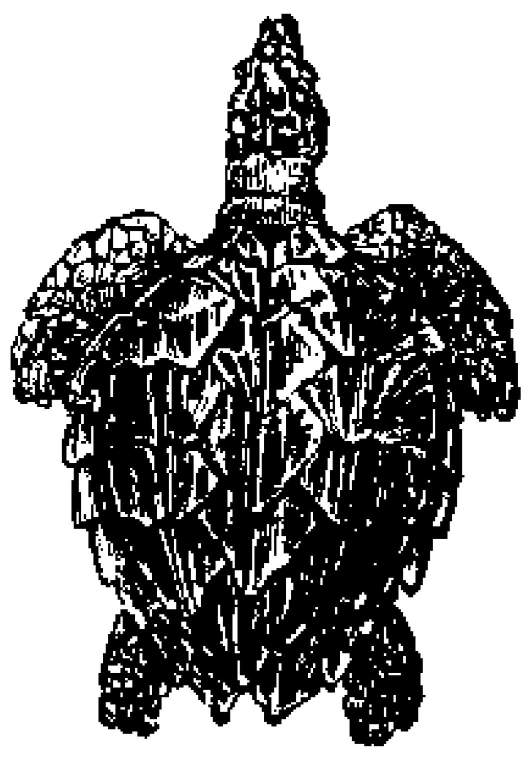
Bernardin de St. Pierre gives us the following picturesque description of turtle-catching on Ascension Island;—"Fire-wood, a kettle, and the great boat-sail were landed, and the sailors lay down to sleep, as the turtles do not emerge from the sea before night-fall. The moon rose above the horizon and illumined the solitude, but her light, which adds new charms to a friendly prospect, rendered this desolate scene more dreary still. We were at the foot of a black hillock, on whose summit mariners had planted a great cross. Before us lay the plain, covered with innumerable blocks of black lava, whose crests, whitened by the drippings of the sea-birds, glistened in the moonbeam. These pallid heads on dark bodies, some of which were upright, and others reclined, appeared to us like phantoms hovering over tombs. The greatest stillness reigned over this desolate earth, interrupted only from time to time by the breaking of a wave, or the shriek of a sea-bird. We went to the great bay to await the arrival of the turtles, and there we lay flat upon the sand in the deepest silence, as the least noise frightens the turtles, and causes them to withdraw. At last we

saw three of them rising out of the water, and slowly creeping on shore, like black masses. We immediately ran up to the first, but our impatience caused it to drop immediately again into the sea, where it escaped our pursuit. The second, which had already advanced too far, was unable to retreat; we turned it on its back. In this way we caught about fifty turtles, some of which weighed five hundred pounds. Next morning, at ten, the boat came to fetch the produce of our nocturnal sport. This work occupied us the whole day, and in the evening the superfluous turtles were restored to the sea. If suffered to remain a long time on their back, their eyes become blood-red, and start out of their sockets. We found several on the strand that had been allowed to perish in this position, a cruel negligence, of which thoughtless sailors are but too often guilty."

In the sea, also, the turtles are pursued by man. In the clear West Indian waters, where they are frequently seen at great depths, feeding on the sea-grass meadows, divers plunge after them and raise them to the surface. Sometimes they are harpooned, or even caught sleeping on the waters.

The ancient Romans, who spent such extravagant sums upon dishes repugnant to our taste, seem to have had but little relish for turtle flesh, which otherwise the conquerors of the world might easily have obtained from the Red Sea; for though we read that Vitellius feasted upon the brains of pheasants, and the tongues of nightingales, it is nowhere mentioned, that he ever, like the Lord Mayor of London, set seven hundred tureens of turtle soup before his guests.

On the other hand, they made a very extensive use of tortoise-shell, the produce of the Hawk's-bill turtle (*Testudo imbricata*) a native both of the American and Asiatic seas, and sometimes, but more rarely, met with in the Mediterranean. The flesh of the animal is not held in any estimation as a food, but the plates of the shell being thicker, stronger, and cleaner than those of any other species, render it of great importance as an article of trade.



Hawk's-bill Turtle.

"Carvilius Pollio," says Pliny, "a man of great invention in

matters pertaining to luxury, was the first who cut the plates of the tortoise for veneering or inlaying." The Romans imported large quantities of this precious article from Egypt, and under the reign of Augustus, the wealthy patricians used even to inlay the doors and columns of their palaces with it. When Alexandria was taken by Julius Cæsar, the warehouses were so full of tortoise-shell that the conqueror proposed to make it the principal ornament of his triumph.

The use of tortoise-shell for the decoration of houses and furniture is long since out of fashion, but it is still in great request for the making of combs and boxes. By steeping it in boiling water it softens, and may then, by a strong pressure, be moulded into any form. When a considerable extent of surface is required, different pieces must be joined together. This is done by scraping thin the edges of the pieces to be united, and laying them over each other while they are in the heated and softened state; strong pressure being then applied, they become comletely agglutinated. It is in this way that gold, silver, and other metals for different ornaments are made to adhere to tortoise-shell.

When, at the beginning of the chapter, I mentioned that the lizards had entirely forsaken the ocean, I forgot that the Galapagos Islands in the South Sea, right under the Equator, exclusively possess a maritime animal of this kind, which, from its being the sole existing representative, or dwindled descendant of the giant oceanic saurians of yore, is far too interesting to be passed unnoticed. This lizard is extremely common on all the islands throughout the Archipelago. It lives exclusively on the rocky sea-beaches, and is never found,— at least Mr. Darwin never saw one,—even ten yards inshore. It is a hideous-looking creature, of a dirty black colour, stupid and sluggish in its movements. The usual length of a full-grown one is about a yard, but there are some even four feet long. These lizards were occasionally seen some hundred yards from

the shore, swimming about; and Captain Collnett, in his "Voyage," says they go out to sea in shoals to fish. With respect to the object, Mr. Darwin believes he is mistaken; but the fact, stated on such good authority, cannot be doubted. When in the water the animal swims with perfect ease and quickness by a serpentine movement of its body and flattened tail; the legs, during this time, being motionless and closely collapsed on its sides. A seaman of the "Beagle" sank one with a heavy weight attached to it, thinking thus to kill it directly; but when an hour afterwards he drew up the line the lizard was quite active. Their limbs and strong claws are admirably adapted for crawling over the rugged and fissured masses of lava, which every where form the coast. In such situations a group of six or seven of these hideous reptiles may oftentimes be seen on the black rocks, a few feet above the surf, basking in the sun with outstretched legs.

Mr. Darwin opened the stomach of several, and in each case found it largely distended with minced sea-weed, of a kind growing at the bottom of the sea, at some little distance from the coast. The nature of this lizard's food, as well as the structure of its tail, and the certain fact of its having been seen voluntarily swimming out at sea, absolutely prove its aquatic habits; yet there is in this respect one strange anomaly, namely, that when frightened it will not enter the water. From this cause it is easy to drive these lizards down to any little point overhanging the sea, where they will sooner allow a person to catch hold of their tail than jump into the water. They do not seem to have any notion of biting; but when much frightened they squirt a drop of fluid from each nostril. One day Mr. Darwin carried one to a deep pool left by the retiring tide, and threw it in several times as far as he was able. It invariably returned in a direct line to the spot where he stood. It swam near the bottom with a very graceful and rapid movement, and occasionally aided itself over the uneven ground with its feet. As soon as it arrived near the margin, but still being under water, it either tried to conceal itself in the tufts of sea-weed, or it entered some crevice. As soon as it thought the danger was past, it crawled out on the dry rocks and shuffled away as quickly as it could. Mr. Darwin several times caught this same lizard by driving it

down to a point, and, though possessed of such perfect powers of diving and swimming, nothing could induce it to enter the water; and as often as he threw it in, it returned in the manner above described.

Perhaps this singular piece of apparent stupidity may be accounted for by the circumstance that this reptile has no enemy whatever on shore, whereas at sea it must often fall a prey to the numerous sharks. Hence, probably urged by a fixed and hereditary instinct that the shore is its place of safety, whatever the emergency may be, it there takes refuge. On a comparison of this singular animal with the true iguanas, the most striking and important discrepancy is in the form of the head. Instead of the long pointed narrow muzzle of those species, we have here a short obtusely truncated head, not so long as it is broad; the mouth consequently is capable of being opened to only a very small extent. From this circumstance, and from the crest on its head, it has received the Latin name of *Amblyrhynchus cristatus*.

The serpent race, which thrives so abundantly in the tropical forests and morasses, has also its marine representatives in the Indian and Pacific Oceans, where more than fifty species of Hydrophis, Pelamys, and Chersydra have been found. They are distinguished from their terrestrial relations by the flattened form of their tail, the planes of which being directed vertically give it the properties of a powerful oar, in striking the water by lateral oscillations. These sea-snakes always appear to prefer calms, swimming on the still surface in an undulating manner, never raising the head much from the surface, or vaulting out of the water. They dive with facility on the approach of danger, but do not appear to be particularly timid.

Water-Snake.

The Pelamys bicolor is very common from India to Otaheite. In the seas of Mindoro and Sooloo, Mr. Adams saw thousands swimming on the top of the water, especially in eddies and tide-ways where the ripple collects numerous fish and medusæ, which principally constitute their prey. Their tongue is white and forked, differing in

respect of its colour from the tongue of other snakes, which is generally black. The water-snakes, which are frequently beautifully banded, and as thick as a man's leg, are said to be highly venomous. Captain Cook, in one of his voyages, "saw abundance of water-snakes, one of which was coming up the side of our ship, and our men beat it off. The Spaniards affirm there is no cure for such as are bit by them; and one of our blacks happened to fall under that misfortune, and died notwithstanding the utmost care was taken by our surgeons to recover him."

Such are the *real* sea-snakes as they are met with by ordinary travellers, while *the great sea-serpent*, which from time to time dives up in the columns of the newspapers, must, until better evidence be brought forward for its existence, be banished to those dim regions peopled by unicorns, griffins, krakens, and tailed men.

Olaus Magnus, it is true, speaks of the great sea-snake as if it made its daily appearance on the Norwegian coast. According to him, it inhabits the rocky caves near Bergen, and wanders forth at night, particularly by moonshine, to commit its depredations by sea and land; as calves and pigs seem to suit its appetite as well as fishes and lobsters. The body is covered with scales, a long mane flows along the neck, and the head, furnished with two glistening eyes, rises like a mast out of the water. It often attacks ships, and picks up seamen from the deck. This description may serve as an example of the boldness with which authors have sometimes asserted the most extravagant things.

The Greenland missionary Egede tells us in his Journal, that "on the 6th of July, 1734, there appeared a very large and frightful sea-monster, which raised itself so high out of the water that its head reached above our main-top. It had a long sharp snout, very broad flappers, and spouted water like a whale. The body seemed to be covered with scales, the skin was uneven and wrinkled, and the lower part was formed like a snake. After some time the creature plunged backwards into the water, and then turned its tail up above the surface, a whole ship-length from the head."

It is hard to disbelieve so pious and excellent a man, whose excited fancy no doubt gave extraordinary forms and dimensions

to some commoner sea-animal of large size; but the testimony of a Scoresby, who during his frequent Arctic voyages never saw anything of the kind, would have been more convincing.

If to this account of Egede be added the reports of some other northern divines, such as Pontoppidan, the missionary Nicholas Græmius, and Maclean, who either pretend to have actually seen the monster or write about it from hearsay—and the testimony of a few seamen, among others of Captain M'Quhae of the Dædalus, who, on the 6th of August, 1848, saw a sea-snake on his homeward voyage from the East Indies; we have all the evidence extant in favour of the existence of the monstrous animal.

In opposition to these testimonies, incredulous naturalists beg to remark, that no museum possesses a single bone of the huge snake, and that its body has nowhere been found swimming on the ocean or cast ashore. They therefore agree with Professor Owen in regarding the negative evidence, from the utter absence of any recent remains, as stronger against their actual existence than the positive statements which have hitherto weighed with the public mind in favour of their reality; and believe that a larger body of evidence from eye-witnesses might be got together in proof of the reality of ghosts than in proof of the existence of the great sea-serpent.

The plain truth seems to be that lines of rolling porpoises, resembling a long string of buoys, first gave origin to the marvellous stories of the fabulous monster. For, keeping in close single file, and progressing rapidly along the calm surface of the water by a succession of leaps or demivaults forward, part only of their uncouth forms appears to the eye, so as to resemble the undulatory motions of one large serpentiform animal.

CHAP. XII.

THE MARINE FISHES.

General Observations on Fishes — Their Locomotive Organs — Tail — Fins.— Classification of Fishes by Cuvier.— Air-Bladder.—Scales. — Beauty of the Tropical Fishes. — The Gills. — Terrestrial Voyages of the Anabas and the Hassar. — Examples of Parental Affection. — Organs of Sense. — Offensive Weapons of Fishes.—The Sea-Wolf.—The Shark.—The Saw-Fish.—The Sword-Fish.— The Torpedo.— The Star-Gazer. — The Angler.—The Chætodon Rostratus. — The Remora, used for catching Turtles. — Defensive Weapons of Fishes.—The Weever.—The Stickleback.—The Sun-Fish.—The Flying-Fish.— The numerous Enemies of the Fishes.—Importance and History of the Herring Fishery.—The Pilchard.—The Sprat.—The Anchovy.—The Cod.—The Sturgeons.—The Salmon.—The Tunny.—The Mackerel Family.—The Eel.—The Murey.—The Conger.—The Sand-Launce.—The Plectognaths.—The Sea-Horse. —The Pipe-Fish.—The Flat-Fishes.—The Rays.—The Fecundity of Fishes.

The bosom of the ocean is full of mysteries; it conceals a whole world of curiously-shaped animals, which the naturalist only superficially knows, and may, perhaps, never be able to fathom. To observe the habits of terrestrial animals, and accurately to determine their various species, is a comparatively easy task; but the denser element in which fishes live prevents us from following their motions with exactness, from studying their instincts, and from noting with fidelity their specific differences.

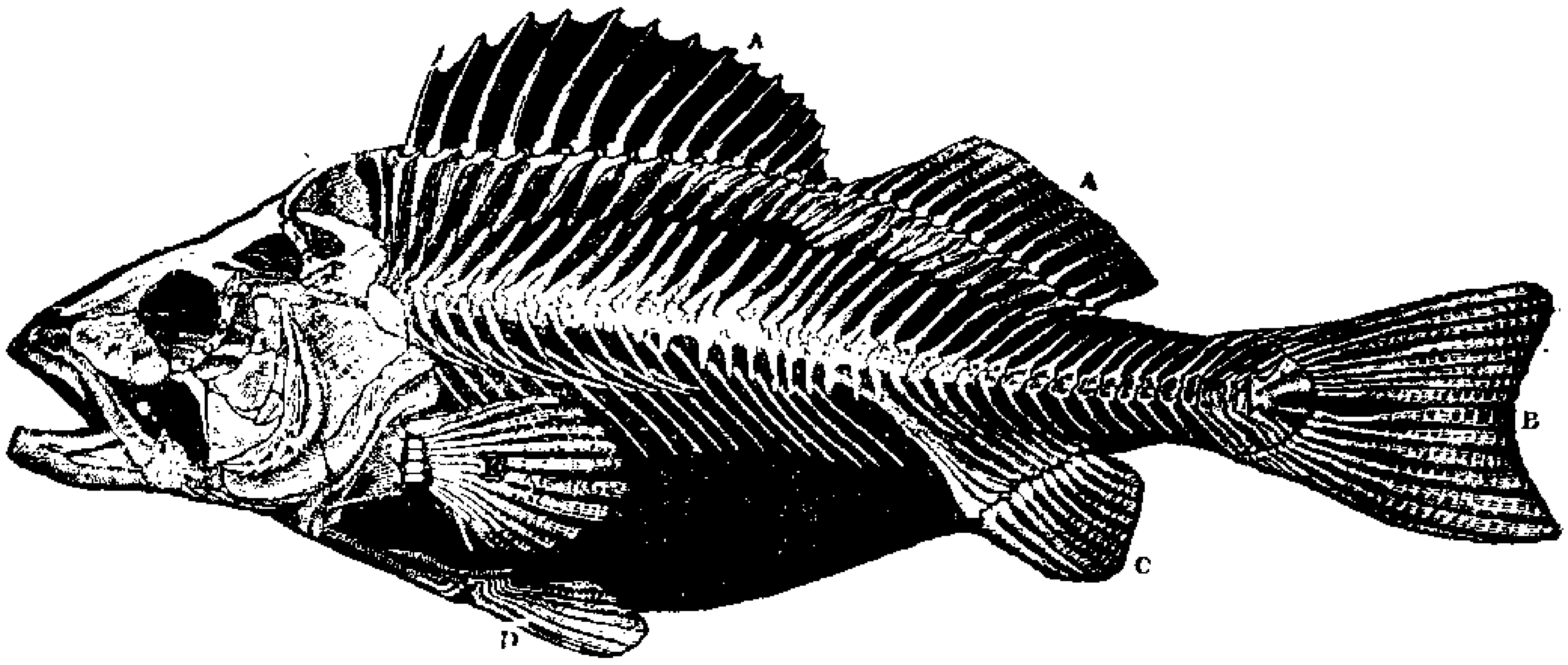
Since Pliny, who mentions but seventy-four different kinds of fishes, the number of known species has indeed enormously increased. The ancients, who knew only the waters of the Mediterranean and a very small part of the ocean, had no conception of the finny multitudes inhabiting the tropical and icy seas; but although modern science has succeeded in describing and picturing above eight thousand different kinds of fishes, yet there can be no doubt that many still unknown species dwell in the depths of ocean, or in the distant seas which are but seldom visited by the European mariner.

If the whole economy of the world of fishes were opened to our view, the magnificent picture would, no doubt, give us additional reasons for admiring the infinite wisdom of the Creator; but the little we do know suffices to convince us that the same wonderful harmony existing between the anatomical structure and the outward relations or mode of life in birds and mammiferous quadrupeds is also to be found in fishes, and that these creatures, though occupying a lower grade in Creation, are no less beautifully adapted to the peculiar element in which they are destined to live and move.

This strikes us at once in their external form, which, though subject to great variety, being sometimes spherical as in the globe-fish, or cubical as in the ostracion, or expanded as in the skate, or snake-like as in the eel, is generally that of an elongated oval, slightly compressed laterally, a shape which enables the fishes to traverse their native fluid with the greatest celerity and ease. We wisely endeavour to imitate this peculiar form in the construction of our ships, yet the rapidity with which the fastest clipper cleaves the waters is nothing to the velocity of an animal formed to reside in that element. The flight of an arrow is not more rapid than the darting of a tunny, a salmon, or a gilt-head through the water. It has been calculated that a salmon will glide over 86,400 feet in an hour, that it will advance more than a degree of the meridian of the earth in a day, and that it could easily make the tour of the world in some weeks, were it desirous of emulating the fame of a Cook or of a Magellan. Every part of the body seems exerted in this despatch; the fins, the tail, and the motion of the whole backbone assist progression; and it is to this admirable flexibility of body, which mocks the efforts of art, that fishes owe the astonishing rapidity of their movements.

Whales and dolphins move onwards by striking the water in a vertical direction, while fishes glide along by laterally curving and extending the spine. In some species, such as the eel, the whole body is flexible; but most of them paddle away with their tail to the right and left, and are thus driven forwards by the resistance of the water. Consequently the power of fishes is chiefly concentrated in the muscles bending the spine sideways, and generally we find these parts so much developed as to form the greatest part of the body.

The fins are the most important auxiliary organs of locomotion in fishes. The dorsal, caudal, and anal fins serve by their vertical position to increase the extent of the rowing surface, and to maintain the animal's balance, while the pectoral and



Skeleton of the Perch.

A A, Dorsal Fins ; B, Caudal ; C, Anal ; D, Ventral , E, Pectoral.

ventral fins, which must be considered as the representatives of the fore and hind limbs of other vertebrata, are, moreover, of great assistance in directing its movements. With the help of these organs, fishes can advance or retrograde, ascend or descend in the water as they please, and it is curious to observe how, alternately extending or contracting one fin or the other, they gracefully plough the liquid element in every direction.

It is no less wonderful how perfectly the size and texture of the fins corresponds with the habits and necessities of the different species of fishes. Those which traverse vast portions of the ocean, or have frequently to struggle against swelling waves, are furnished with large and strong fins, while these organs are soft in the species which confine themselves to greater depths, where the winds cease to disturb the waters.

From the great variety which is met with both in the number and position of the fins, they are also of the greatest use in the classification of fishes, and afford the naturalist many of the chief characters which serve to distinguish the several orders, families, genera, and species of these aquatic vertebrates.*

* Cuvier divides the fishes into:

I. Chondropterygii—Skeleton cartilaginous; fins supported by cartilaginous rays; and

II. Osteopterygii—Skeleton composed of true bone.

Most fishes possess a remarkable accessory organ of locomotion in the air-bladder or swim-bladder which extends to a greater or smaller distance along the ventral surface of the spine, and enables them voluntarily to increase or diminish the specific gravity of their body. When they contract this remarkable gas-reservoir, or press out the included air by means of the abdominal muscles, the bulk of the body is diminished, its weight in proportion to the water is increased, and the fish swims easily at a greater depth. The contrary takes place on relaxing the tension of the abdominal muscles; and thus we see fishes rise and fall in their denser element by the application of the same physical law which is made use of by our aëronauts, to scale the heavens or to descend again upon the

The Chondropterygii are subdivided into three orders:

(*a*) Sturionidæ (sturgeons), with free gills.

(*b*) Selacii (rays, sharks), with gills fixed and a mouth formed for mastication.

(*c*) Cyclostomata (lamprey, myxine), with gills fixed and a mouth formed for suction.

The osseous fishes, which are far more numerous, are subdivided into six orders:

(*a*) Acanthopterygii; distinguished by the stiff spines which constitute the first fin-rays of the dorsal fin, or which support the anterior fin of the back in case there are two dorsals. In some cases the anterior dorsal fin is only represented by detached spines. The first rays of the anal fin are likewise spinous, as well as the first ray of the ventral fin. To this extensive order, which comprises about three-fourths of the osseous fishes, belong, among others, the families of the perches, gurnards, mackerels, mullets, breams, gobies, blennies, &c.

The three following orders of the osseous fishes have the rays that support the fins soft and composed of numerous pieces articulated with each other, with the exception in some cases of the first ray of the dorsal, or of the pectoral. Their leading character is afforded by the situation or absence of the ventral fin, which in the

(*b*) Malacopterygii abdominales are suspended beneath the abdomen, and behind the pectorals; in the

(*c*) Malacopterygii subbrachiales beneath the pectorals; and in the

(*d*) Malacopterygii apodes are totally wanting.

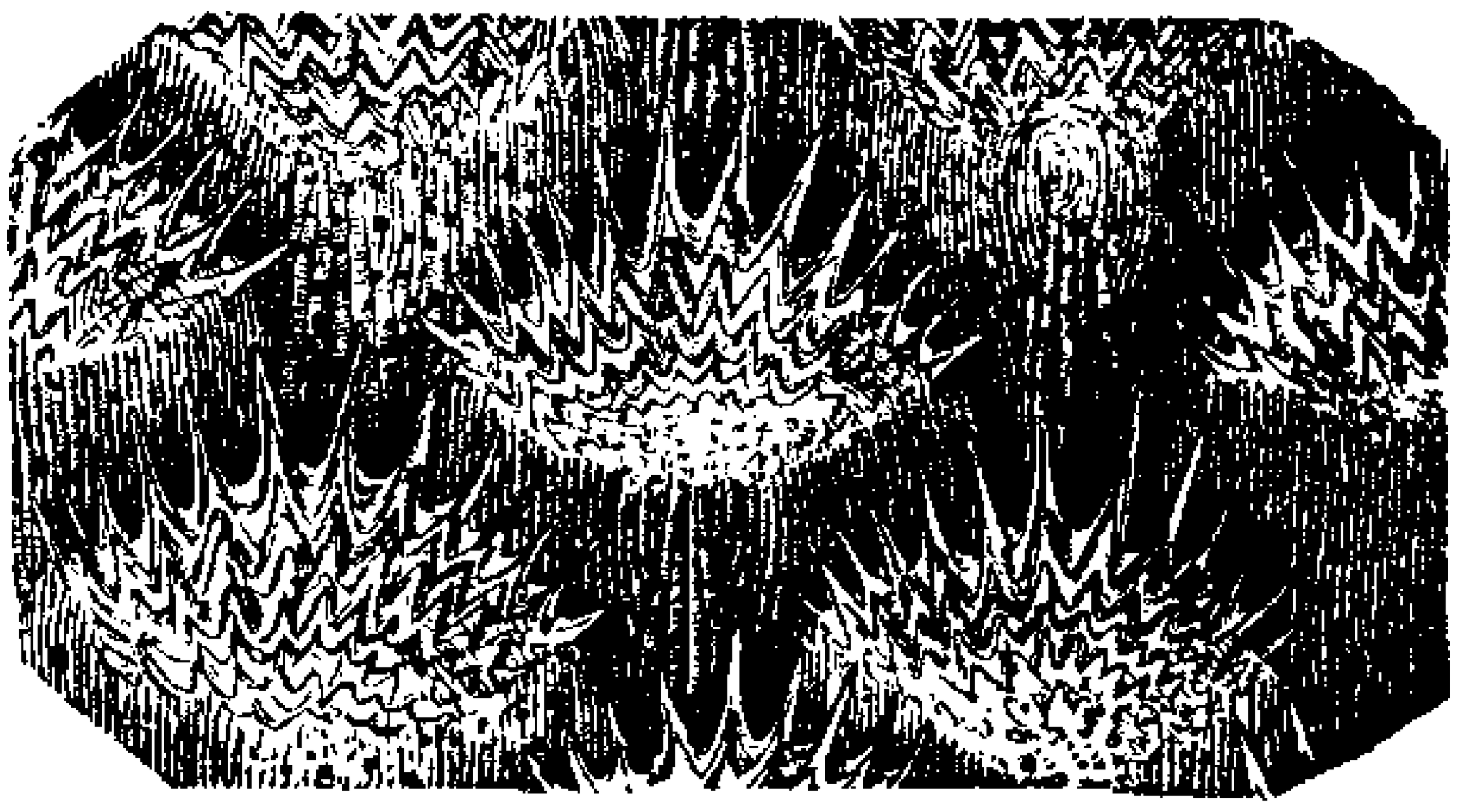
To the abdominal soft-rayed fishes belong the herring, salmon, pike, sly, and carp families; to the subbrachial, the cod family, the side-swimmers, and the lump fishes; and, finally, to the apodal malacopterygians, the single family of the anguilliform fishes. The small order of the

(*e*) Lophobranchi comprises the pipe-fishes, sea-horses, in whom the gills are not pectinated, as in the preceding subdivisions, but consist of little round tufts; and, finally, the

(*f*) Plectognathi—comprising the file, porcupine, and sun fishes—are distinguished by their maxillaries and premaxillaries being joined immovably to each other, so as to render the upper jaw incapable of protrusion.

earth. Those fishes which are destined to live at the bottom of the sea or to conceal themselves in the mud, such as eels and skates, have either no air-bladder or a very small one—for economical Nature gives none of her creatures any organ that would be useless to them. Even the slimy glutinous matter which is secreted from the pores of most fishes, and lubricates their bodies, assists them in gliding through the waters, so that no means have been neglected to promote the rapidity of their movements.

The skin of fishes is but seldom naked; in most species it is covered with scales, that sometimes appear in the form of osseous plates, as in the ostracions, or project into formidable prickles, as in the porcupine-fish, but generally offer the aspect of thin laminæ, overlapping each other like the tiles of a roof, and embedded, like our nails, in furrows of the skin. In nearly all the existing fishes, the scales are flexible and generally either of a more or less circular form (*cycloid*), as in the, salmon, herring, roach, &c., or provided with comb-like teeth projecting from the posterior margin (*ctenoid*), as in the sole, perch, pike, &c.; while the majority of fossil fishes were decked with hard bony scales, either rhomboidal in their form, of a highly polished surface, as in our sturgeons (*ganoid*), and arranged in regular rows, the posterior edges of each slightly overlapping the anterior ones of the next, so as to form a very complete defensive armour to the body; or irregular in their shape and



Portion of Skin of Sole highly magnified.

separately imbedded in the skin (*placoid*), as in the sharks and rays of the present day.

The scales of almost any fish afford admirable subjects for microscopic observation, but more particularly those of the ctenoid kind, which exhibit a brilliancy of reflected light, and a

regularity of structure, such as no human mosaic could ever equal.

Many of our European fishes are richly decorated with vivid colours, but their scaly raiment is generally far from equalling the gorgeous magnificence of the fishes of the tropical seas.

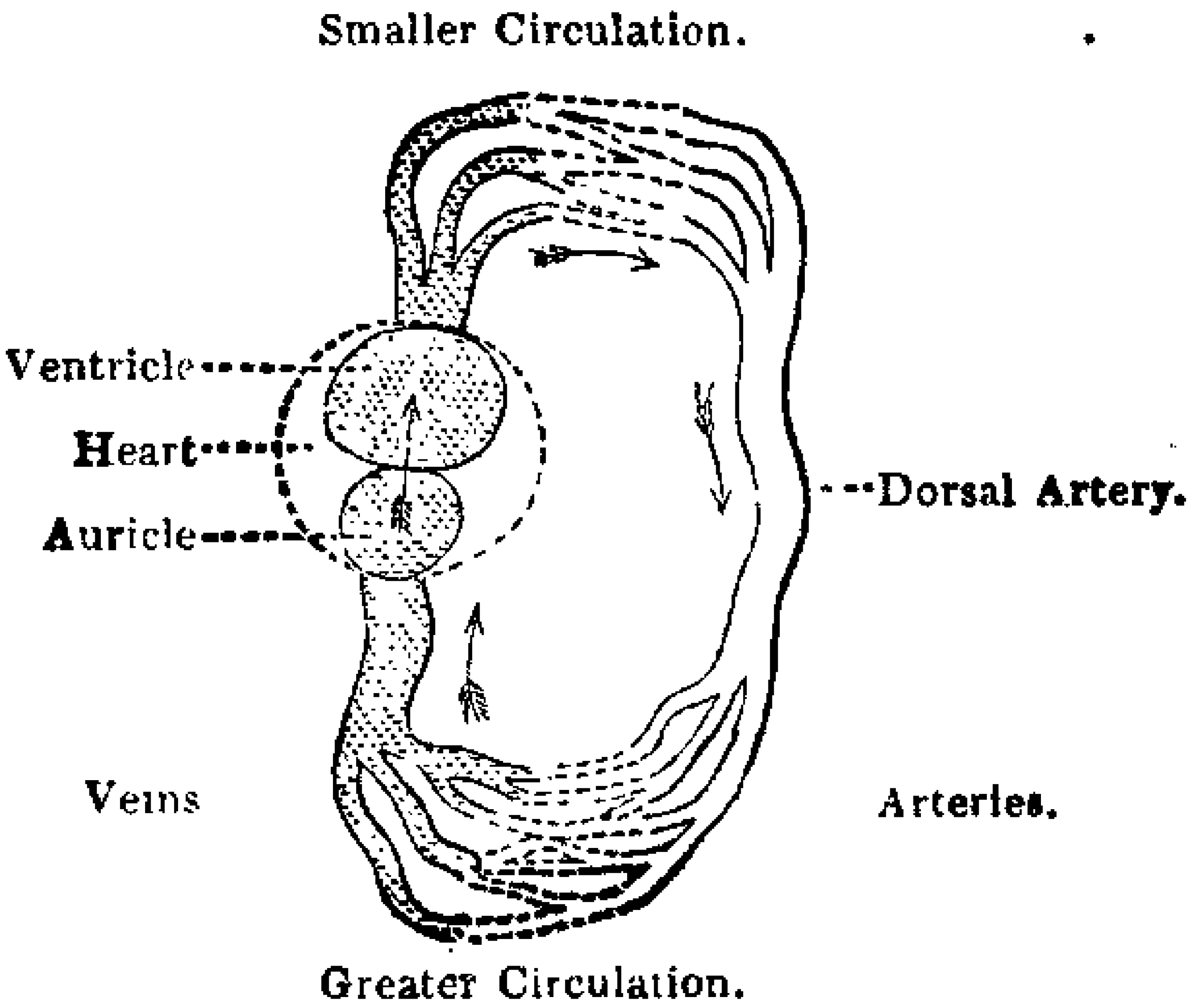
If in the birds of the equatorial zone a part of the plumage sparkles with a gem-like brilliancy, all the colours of the rainbow combine to decorate the raiment of the tropical fishes, and no human art can reproduce the beauty of their metallic lustre, which at every movement in the crystalline waters exhibits to the enchanted eye new combinations and reflections of the most splendid tints.

The gaudiest fishes live among the coral reefs. In the tepid waters, where the zoophytes, those sensitive flowers of the ocean, build their submarine palaces, we find the brilliant Chetodons, the gorgeous Balistinæ, and the azure Glyphysodons gliding from coral branch to coral branch like the playful Colibris, that over the Brazilian fields dart from one lustrous petal to another.

Oxygen is as necessary to fishes and other marine creatures as it is to the terrestrial animals, but as they are obliged to draw it from a denser element, which absorbs but a small volume of air, their gills are necessarily differently constructed from the lungs of the creatures breathing in the atmosphere. In most species, comprising all the bony fishes, and the sturgeons, among those which have a cartilaginous skeleton, we find on either side of the throat five apertures, separated from each other by four crooked, parallel and unequal bones, and leading to a cavity, which is closed on the outside by an operculum or cover. In this cavity, and attached to the bones, are situated the delicate membranes, bearded like feathers, which serve to aërate the blood. The water constantly flows through the gills in one direction, entering by the branchial apertures of the throat, and emerging through the operculum. This is, in more than one respect, a most wise provision of Nature; for if the fishes were obliged to receive and reject the water by the same aperture, as we do the air, each expiration would evidently drive them backwards, and consequently retard their movements. It is also evident that the delicate fringes or folds of the gills would soon get into disorder if the water were carried through them in two opposite directions.

In most of the cartilaginous fishes, such as the sharks, rays, and lampreys, the gills are differently formed, the water not passing into a cavity closed by a cover, but flowing directly outwards through five (in the shark) or seven (in the lamprey) vents or spiracles. In these species also the gills are fixed, their margins being attached. Though the whole breathing apparatus of a fish is comprised in a small compass, its surface, if fully extended, would occupy a very considerable space; that of the common skate, for instance, being equal to the surface of the human body. This single fact may convince us of the numberless ramifications and convolutions of the gills, in which the water is elaborated and attenuated in the course of giving out its air; and how wonderfully Nature has contrived to effect her purpose with the greatest economy of space.

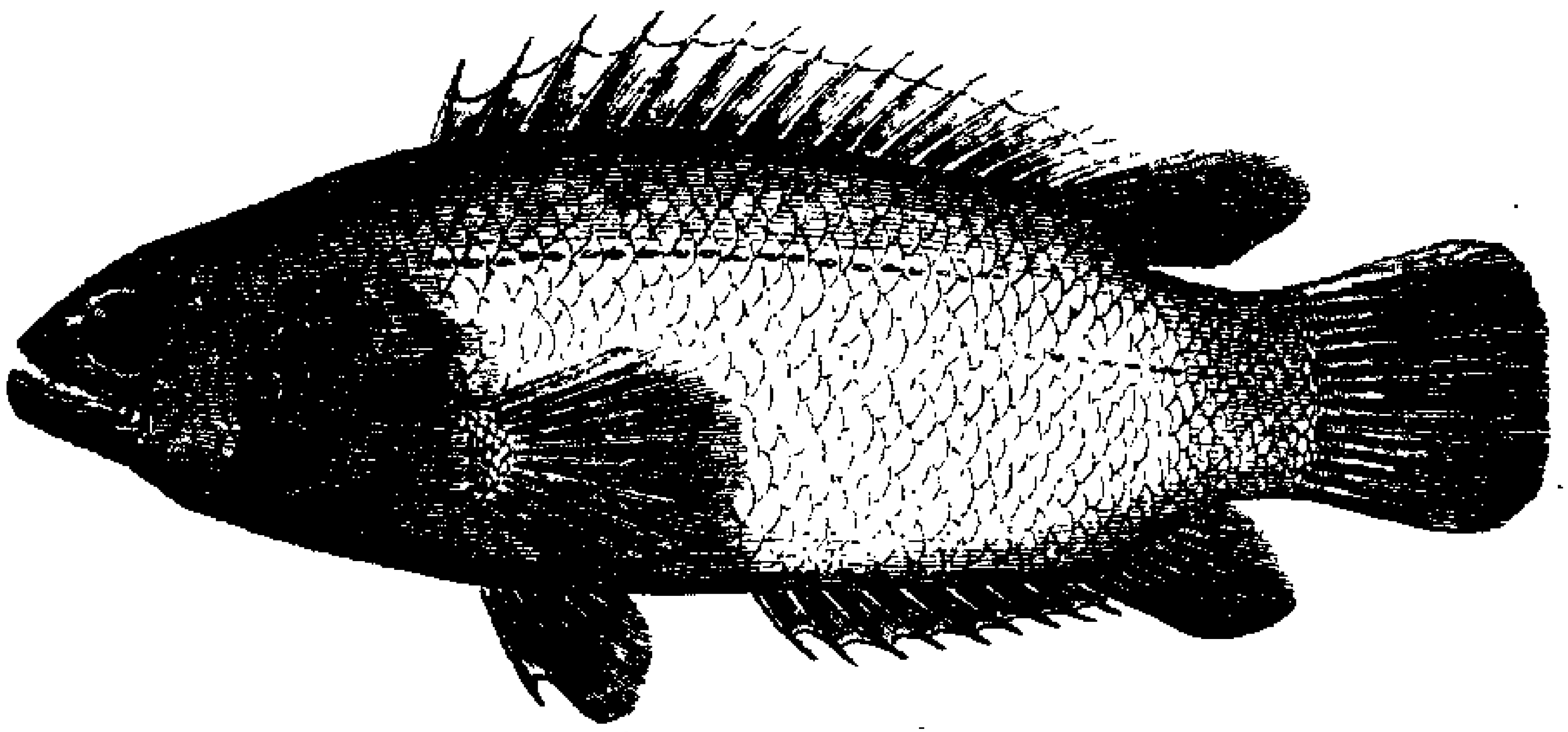
Respiration is a species of combustion, and this must necessarily be very slow in an element which contains so small a portion of oxygen. No wonder that the circulation of the blood



Theoretic representation of the Circulation in Fishes.

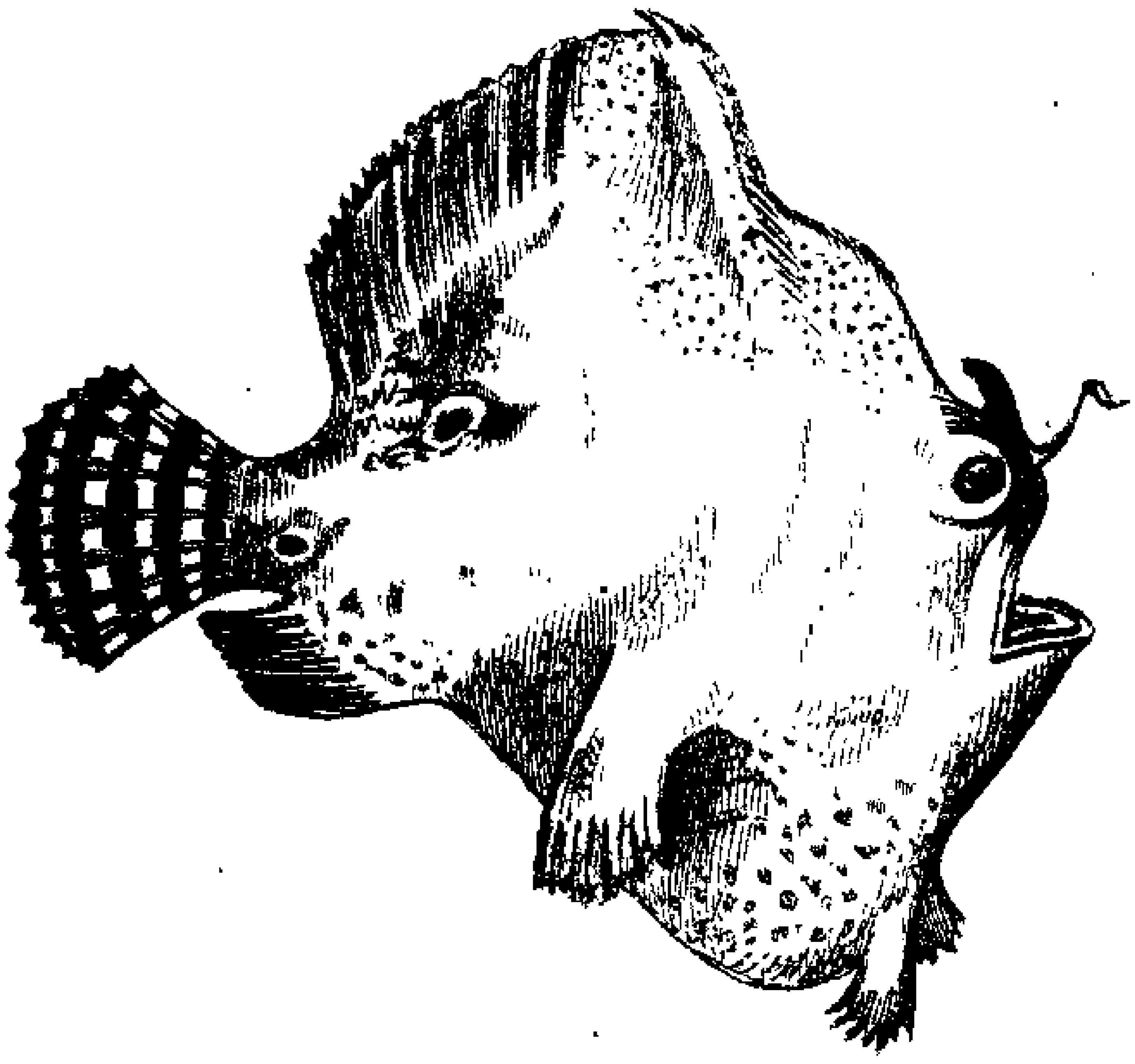
in fishes is equally tardy. Their heart, in comparison with *ours*, *is but half a one*, as it merely serves to force the venous blood into the gills—whence the aërated blood does not flow back to the heart as with us, to be rapidly and strongly propelled through the body, but proceeds immediately to the arteries. Evidently only a cold blood could be formed under such circumstances. It may seem strange that, when fishes are taken out of the water, they die from want of air; such, however, is the case. Their delicate breathing membranes collapse in the atmosphere, the blood can

no longer flow as before into the innumerable small vessels with which they are interwoven, and, by rapidly drying in the air, they soon entirely lose the faculty of breathing. Thus those fishes whose gill-cover has a large aperture, die soonest in the



The Anabas of the Dry Tanks.

air, while those where the opening is narrow, and more particularly those species where the gills communicate with a cellular labyrinth containing water, which serves to keep them moist, are able to live a much longer time in the atmosphere.



Frog-Fish.—(Cheironectes.)

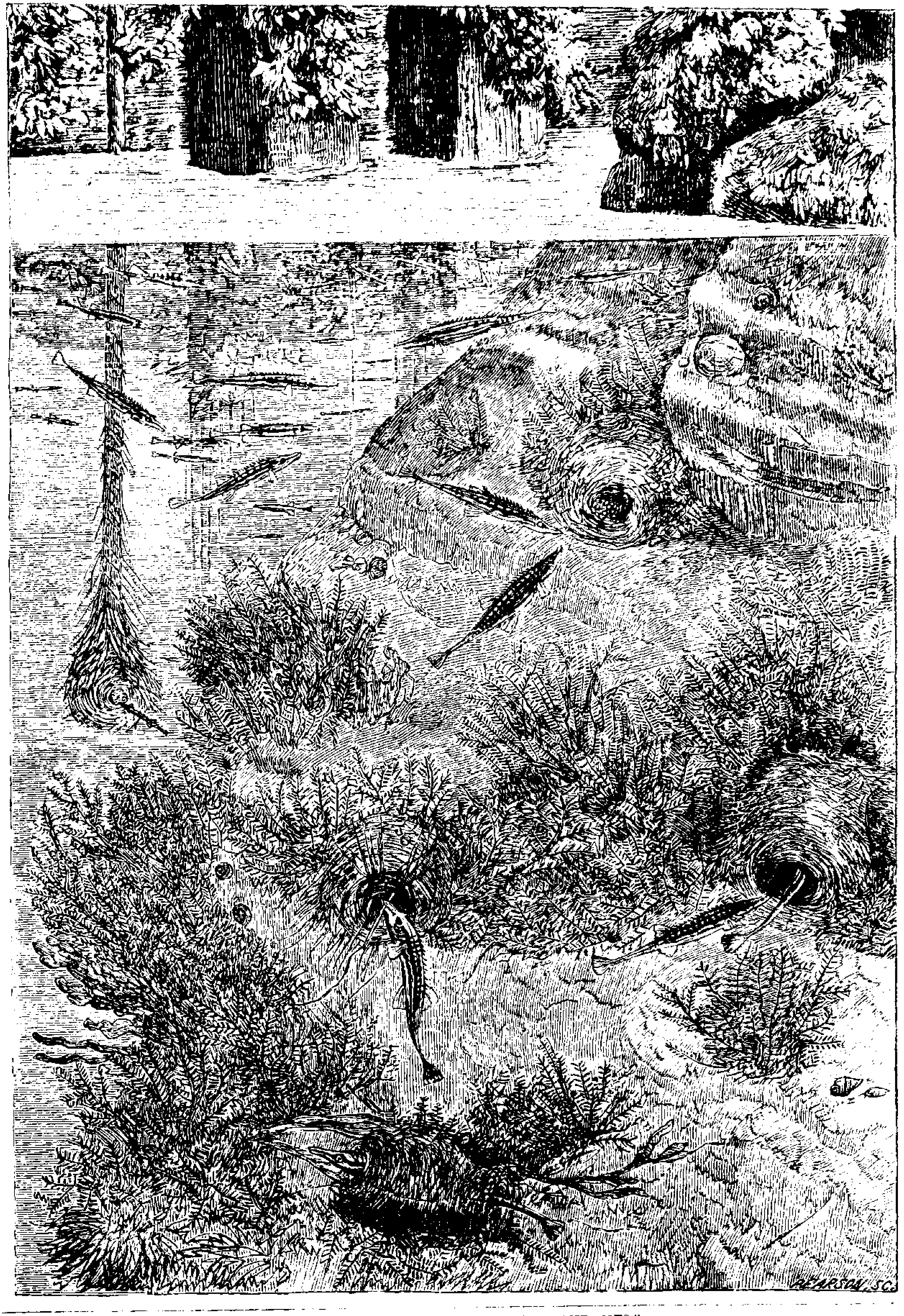
It is owing to such a moistening apparatus that *the climbing fishes* (Anabas) live for days out of the water, and even creep up the trees at some distance from the shore, to catch the insects which serve them as food—a curious instance indeed of an animal seeking its nourishment in another element.

The Frog-fish of the Asiatic islands and the Southern hemisphere is not more remarkable for its hideous deformity than for its capacity of leading a terrestrial life. Not only can it live several days out of the water but it can crawl about the room in which it is confined, a facility which it owes to the great strength and the peculiar position of its pectoral fins, which thus perform the office of feet. The whole aspect of these grotesque-looking creatures, particularly in a walking position, is so much like that of toads or frogs, that a careless observer would at first be at some loss to determine their real nature.

A no less wonderful pedestrian is the Hassar (*Doras costata*), a South American fish, that marches over land in search of water, travelling a whole night when the pools dry up in which it commonly resides. It projects itself forwards on its bony pectoral fins, by the elastic spring of the tail, exerted sidewise, and in this manner proceeds nearly as fast as a man will leisurely walk. The strong scuta or bands which envelop its body must greatly facilitate its march, in the manner of the plates under the belly of serpents, which are raised and depressed by a voluntary power, in some measure performing the office of feet. The Indians say justly that these fishes supply themselves with water for their journey. If they find the pools and rivers everywhere dried up, they bury themselves in the mud, and fall into a kind of asphyxia or lethargy, till the rainy season recalls them again to life.

The hassar is also remarkable for a parental affection, almost unexampled among fishes. Sir Richard Schomburgk relates that it not only builds a complete nest for its spawn but also watches over it with the utmost vigilance till the young brood comes forth. In April, this marine artist begins to build his little dwelling of vegetable fibres, among the waterplants and rushes, until it resembles a hollow ball, flattened at the top. An aperture corresponding to the size of the mother leads into the interior. The parental affection of the fish is shamefully misused by man for its destruction. A small basket is held before the opening; then the nest is slightly beaten with a stick; and, furious, with extended fins, whose sharp points are able to inflict a painful wound, the poor hassar darts into the fatal basket.

The black Goby (*Gobius niger*) also prepares a nest for its



SUBAQUEOUS LIFE—STICKLEBACKS AND NEST.

SUBAQUEOUS LIFE—STICKLEBACKS AND NEST.

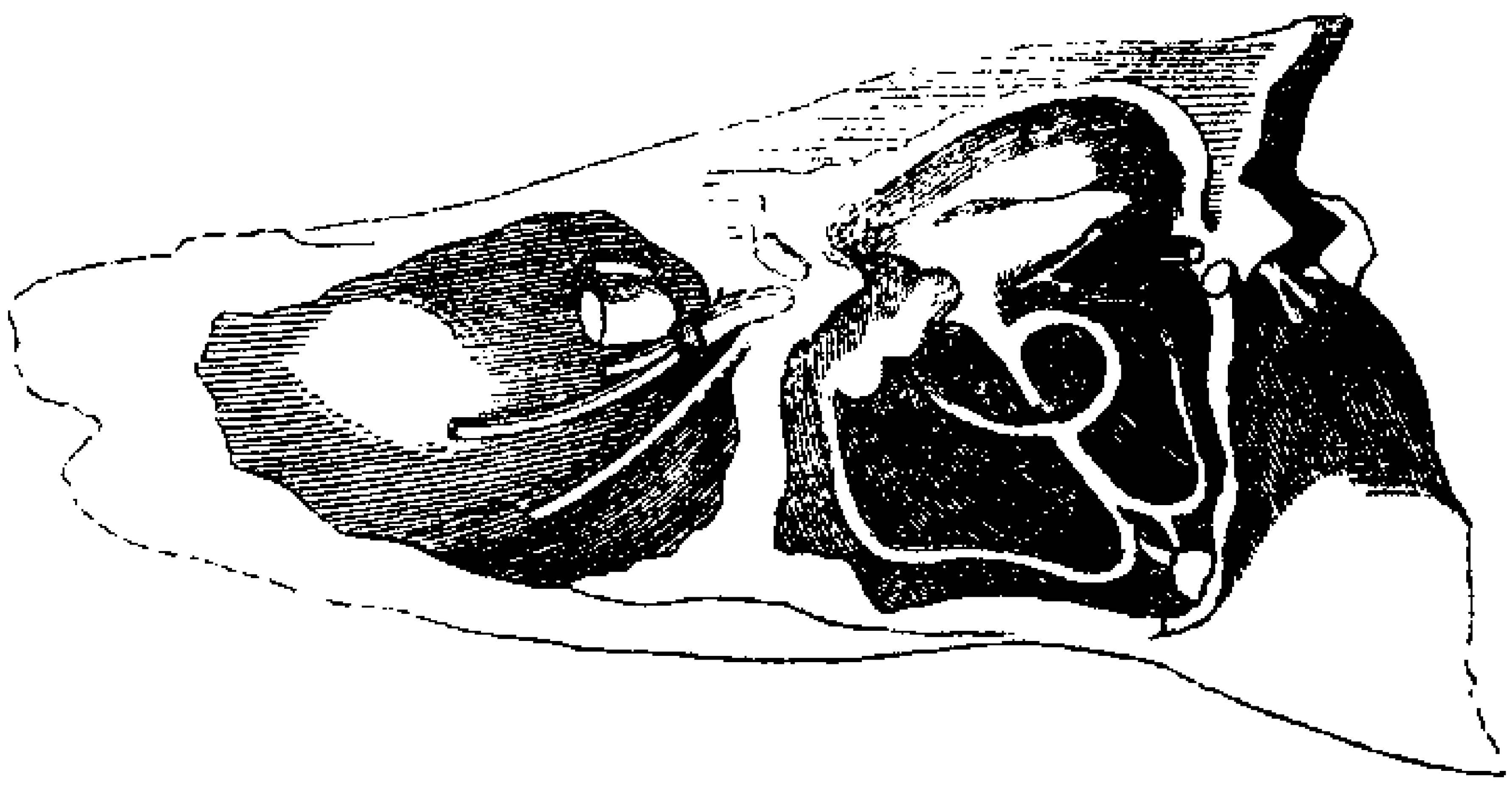
This plate represents a group of fifteen-spined sticklebacks busily employed in making their nests. To the left is seen a curious piece of marine architecture, mentioned by Mr. Couch, the well-known ichthyologist. A pair of sticklebacks had made their nest "in the loose end of a rope, from which the separated strands hung out about a yard from the surface, over a depth of four or five fathoms, and to which the materials could only have been brought, of course, in the mouth of the fish, from the distance of about thirty feet. They were formed of the usual aggregation of the finer sorts of green and red sea-weed, but they were so matted together in the hollow formed by the untwisted strands of the rope that the mass constituted an oblong ball of nearly the size of the fist, in which had been deposited the scattered assemblage of spawn, and which was bound into shape with a thread of animal substance, which was passed through and through in various directions, while the rope itself formed an outside covering to the whole."

eggs. This fish inhabits the slimy bottoms of the lagoons near Venice, and burrows galleries in the clayey soil, where it spends the greater part of the year, protected against storms and enemies. In spring it digs more superficial dwellings among the roots of the sea-grass, to which the spawn attaches itself. The architect watches over the entrance of the house, opposing sharp rows of teeth to every intruder.

A similar care may be admired in the tiny Stickleback, which the celebrated ichthyologist, M. Coste, has often watched building its nest. After the fish has collected the materials, it covers them with sand, glues the walls with a mucous secretion, and prepares a suitable entrance. At a later period it becomes the bold and indefatigable defender of its eggs, repelling with tooth and prickles all other sticklebacks that approach the nest. If the enemy is too powerful, it has recourse to artifice, darts forth, seems actively engaged in the pursuit of an imaginary prey, and often succeeds in diverting the aggressor's attention from its nest. The River Bullhead is likewise said to evince the same parental affection for its ova, as a bird for its nest, returning quickly to the spot, and being unwilling to quit it when disturbed. It is believed, also, of the Lump-Sucker, that the male first keeps watch over the deposited ova, and guards them from every foe with the utmost courage. If driven from the spot by man, he does not go far, but is continually looking back, and in a short time returns. Thus we find among the inferior animals glimpses of a higher nature, which prove that all created beings form a continuous chain, linked together by one all-pervading and almighty Power.

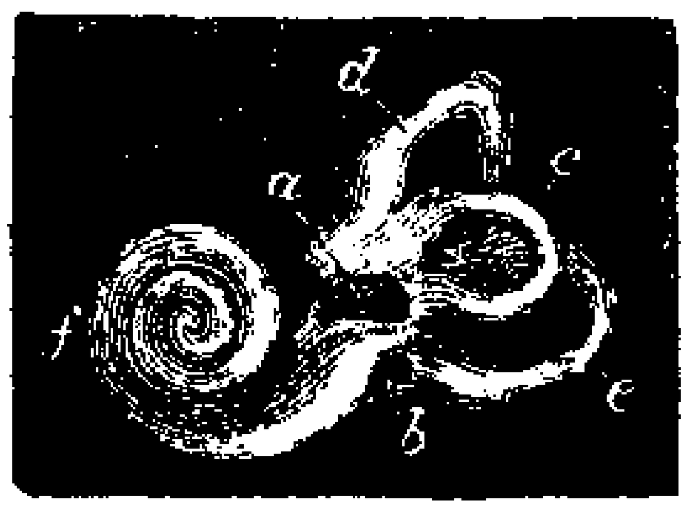
The senses of the fishes are also in perfect harmony with the peculiarities of their mode of life. Their eyes are indeed wanting in the fire and animation which gives so much expression to the physiognomy of the higher animals, but the structure of these organs is admirably calculated for the element in which they are plunged, as the spherical form and great size of the crystalline lens, by concentrating the rays of light, enables them to see with distinctness even through so dense a medium as that which surrounds them. When water is clear, smooth, and undisturbed the sight of fishes is very acute, a circumstance well known to anglers, who prefer a breeze undulating over the surface, as they can then approach much nearer the objects of

their pursuit and practise their *artful dodges* with a much better chance of success. The eyes in fishes are observed to occupy very different positions in different species, but their situation is always such as best to suit the exigencies of the particular fish. Thus in the star-gazer and sea-devil, that watch their prey from a muddy concealment, they are very appropriately placed at the top of the head, while in the flat-fishes, where an eye on the side habitually turned towards the ground would have been useless, the distorted head, by placing both eyes on the same level, affords them an extensive range of view in those various directions in which they may either endeavour to find suitable food or avoid dangerous enemies. That fishes are not deficient in the sense of hearing may be seen at once by the annexed illustrations, which show a marked



Internal Ear of Perch.

similarity of organisation between the human ear and that of the perch. It is well known that they start at the report of a

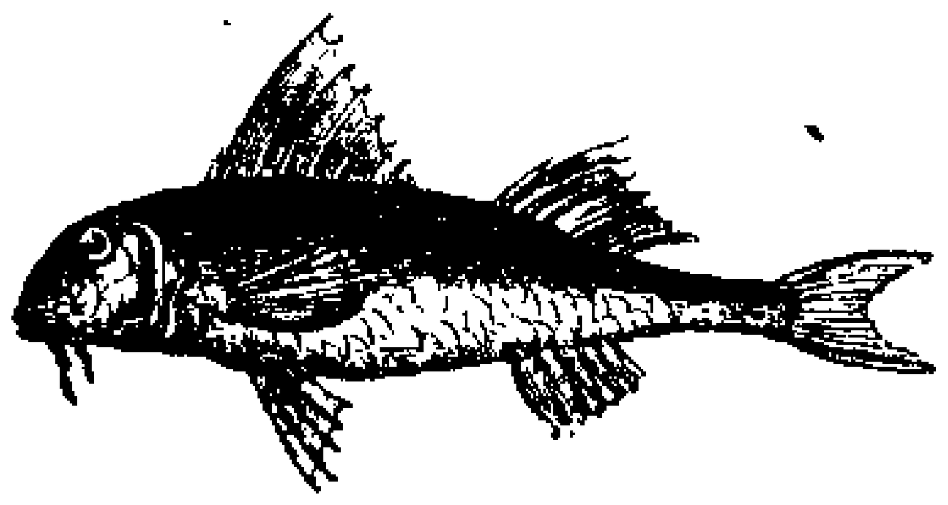


Osseous labyrinth of the Human Ear.

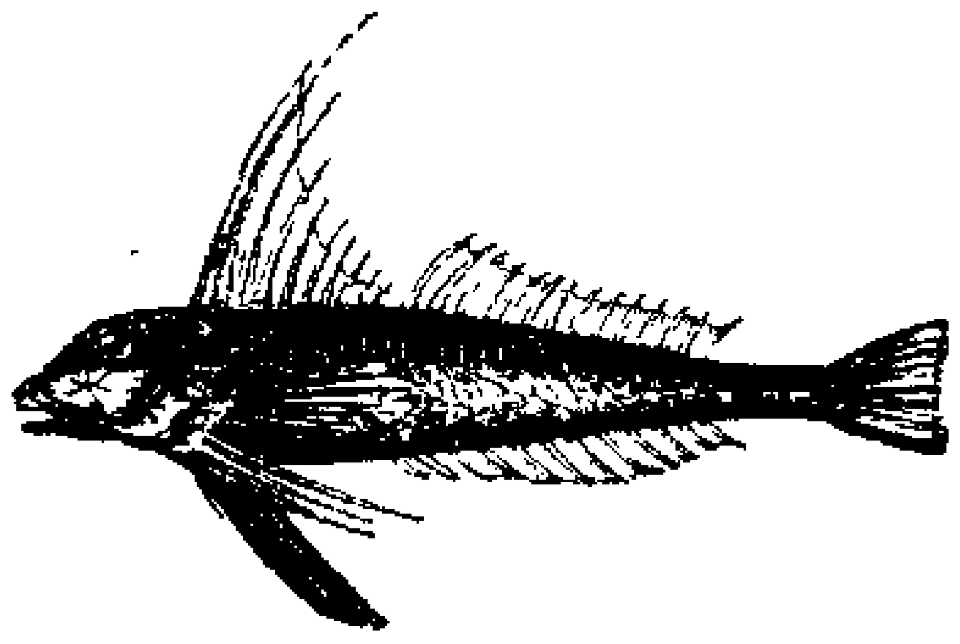
a, Oval or vestibular fenestra; *b*, round or cochlear fenestra; *c*, external or horizontal semicircular canal; *d*, superior or anterior vertical semicircular canal; *e*, posterior or inferior vertical semicircular canal; *f*, the turns of cochlea.

gun, though it is impossible for them to see the flash. Sir Joseph Banks used to collect his fishes by sounding a bell, and the Chinese call the gold-fish with a whistle to receive their

food. In spite of their scaly covering, the fishes are not unprovided with organs of touch. The lips in many species are soft, and the mouths of others, such as the red mullet—for which such enormous sums were paid by the Roman epicures—are provided with barbules largely supplied with nerves, which no doubt enable them to distinguish the objects with which they come in contact. In the three elongated rays of their pectoral fins the gurnards may be said to possess fingers to compensate for their bony lips; and in many other fishes these modified arms or forefeet are applied as organs of feeling to ascertain the character of the bottom of the water. "You may witness the tactile action of the pectoral fins," says Professor Owen,* "when gold-fish are transferred to a strange vessel; their eyes are so placed as to prevent them seeing what is below them; so they compress their air-bladder, and allow themselves to sink near the bottom, which they sweep, as it were, by rapid and delicate vibrations of the pectoral fins, apparently ascertaining that no sharp stone or stick projects upwards, which might injure them in their rapid movements round their prison." Whether fishes possess any high degree of taste is a subject not easily proved; but, to judge by the large size of their olfactory nerves, their sense of smell is probably acute.



Red Mullet.



Gurnard.

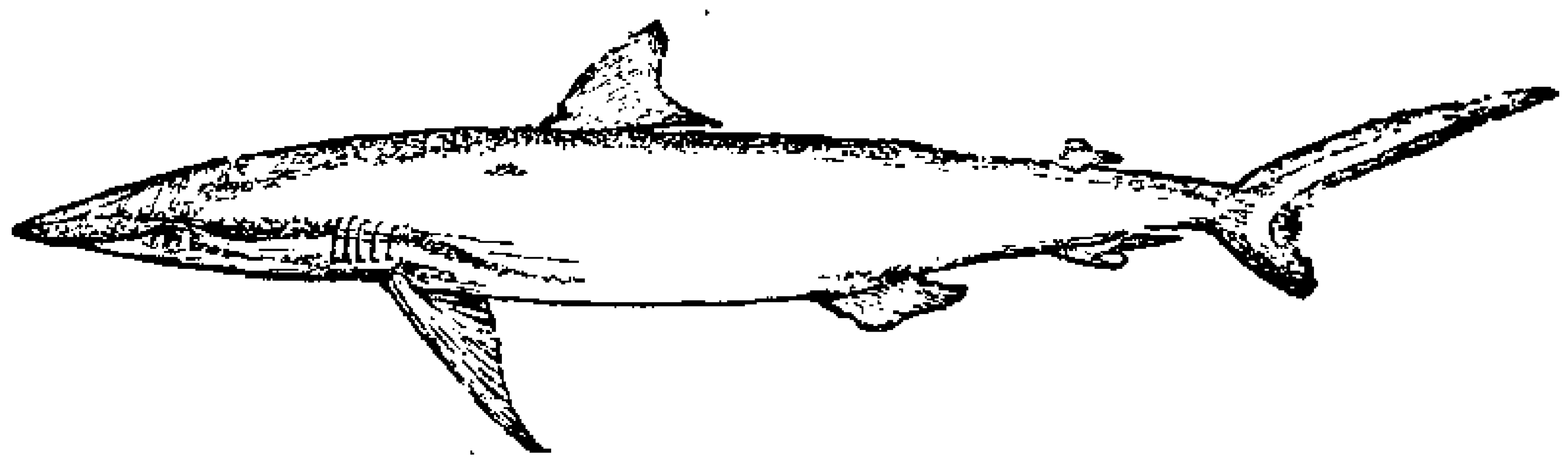
The life of fishes is a state of perpetual warfare, a constant alternation of flight and pursuit. Prowling through the waters, they attack and devour every weaker being they meet, or dart away to escape a similar lot. Many of them are provided, besides their swiftness and muscular power, with the most formidable weapons. Thus the Sea-wolf has six rows of grinders in each jaw, excellently adapted for bruising the crabs and whelks, which this voracious animal grinds to pieces, and swallows along

Wolf-Fish.—(Anarrhicas lupus.

* "Lectures on Comparative Anatomy."

with the shells. When caught, it fastens with indiscriminate rage upon anything within its reach, fighting desperately, even when out of its own element, and inflicting severe wounds if not cautiously avoided. Schönfeld relates that it will seize on an anchor, and leave the marks of its teeth behind, and Steller informs us that one which he saw taken on the coast of Kamschatka frantically seized a cutlass with which it was attempted to be killed, and broke it in pieces as if it had been made of glass. No wonder that the fishermen, dreading its bite, endeavour as soon as possible to render it harmless by heavy blows upon the head. The great size of the monster, which in the British waters attains the length of six or seven feet, and in the colder and more extreme northern seas is said to become still larger, renders it one of the most formidable denizens of the ocean. It commonly frequents the deep parts of the sea, but approaches the coasts in spring to deposit its spawn among the marine plants. Fortunately for its more active neighbours, it swims but slowly, and glides along with the serpentine motion of the eel.

Far more dreadful, from its gigantic size and power, is the White Shark (*Squalus carcharias*), whose jaws are likewise

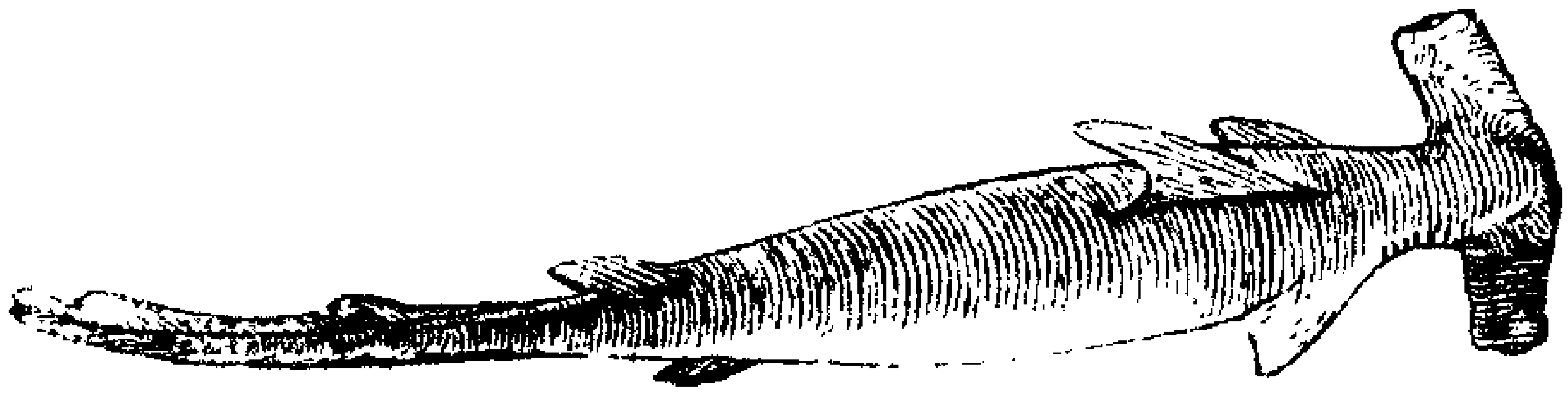


White Shark.

furnished with from three to six rows of strong, flat, triangular, sharp-pointed, and finely serrated teeth, which it can raise or depress at pleasure. This tyrant of the seas grows to a length of thirty feet, and its prodigious strength may be judged of from the fact that a young shark, only six feet in length, is able to break a man's leg by a stroke of its tail. Thus, when a shark is caught with a baited hook at sea, and drawn upon deck, the sailors' first act is to chop off its tail, to prevent the mischief otherwise to be apprehended from its enormous strength. An anecdote related by Hughes, the well-known and esteemed author of the

"Natural History of Barbadoes," gives a good idea of the savage nature of this monster. "In the reign of Queen Anne a merchant-ship arrived at that island from England: some of the crew, ignorant of the danger of the recreation, were bathing in the sea, when a large shark appeared and swam directly towards them; being warned of their danger, however, they all hurried on board, where they arrived safe, except one poor fellow, who was bit in two by the shark, almost within reach of the oars. A comrade, and intimate friend of the unfortunate victim, when he observed the severed trunk of his companion, vowed his revenge. The voracious monster was seen traversing the bloody surface of the waves, in search of the remainder of his prey, when the brave youth plunged into the water. He held in his hand a long sharp-pointed knife; and the rapacious animal pushed furiously towards him. He had turned on his side and opened his enormous jaws, when the youth, diving dexterously, seized the shark with his left hand, somewhere below the upper fins, and stabbed him repeatedly in the belly. The animal, enraged with pain, and streaming with blood, attempted in vain to disengage himself. The crews of the surrounding vessels saw that the combat was decided; but they were ignorant which was slain, till the shark, exhausted by loss of blood, was seen nearer the shore, and along with him his gallant conqueror — who, flushed with victory, redoubled his efforts, and, with the aid of an ebbing tide, dragged him to the beach. Finally, he ripped open the stomach of the fish, and buried the severed half of his friend's body with the trunk in the same grave."

It is no uncommon thing for the negroes, who are admirable divers, thus to attack and vanquish the dreaded shark, but suc



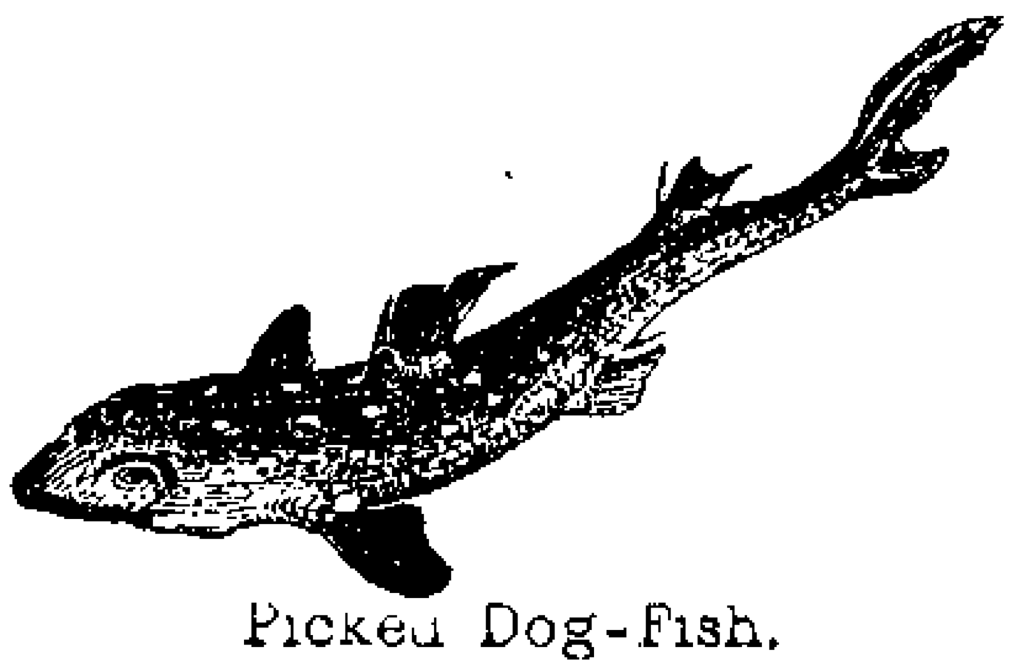
Hammer-headed Shark. — (Squalus Zygæna.)

cess can only be achieved by consummate dexterity, and by those who are armed for this express purpose.

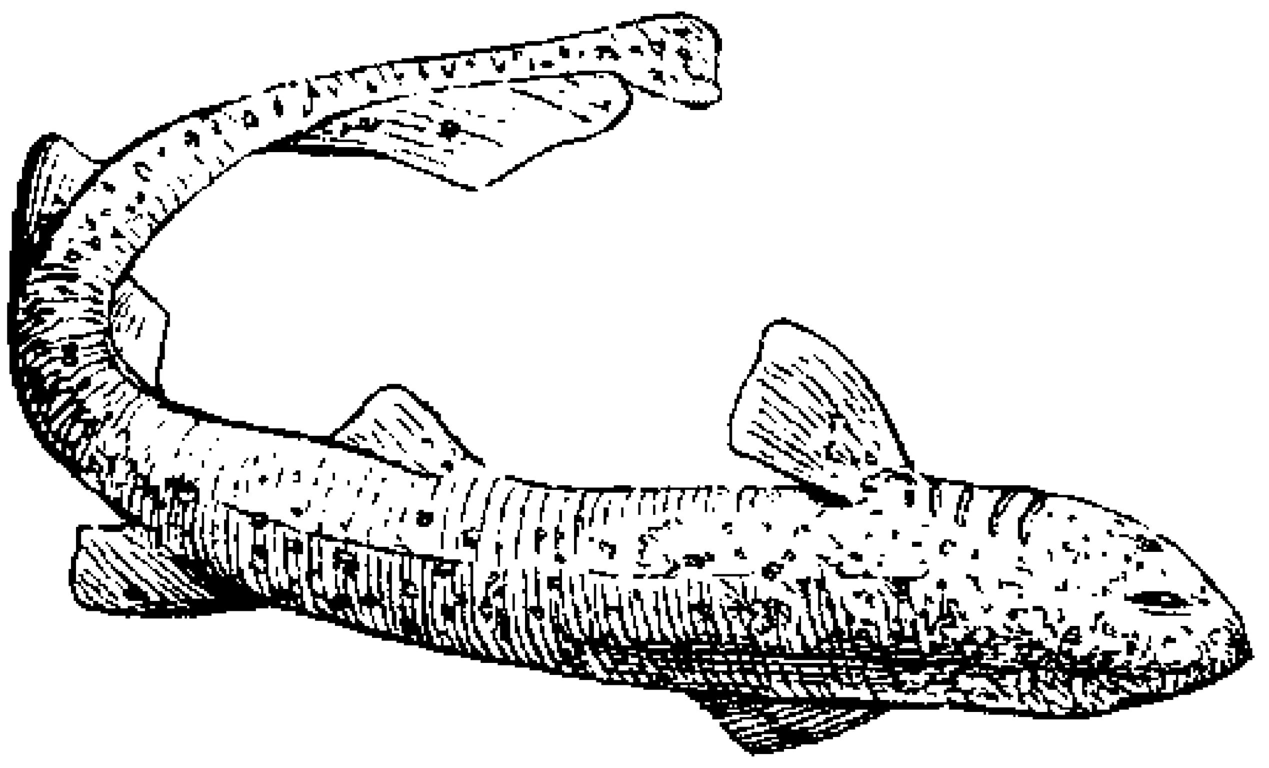
Ordinary swimmers are constantly falling a prey to the sharks of warm climates. Thus Sir Brooke Watson, when in the West Indies, as a youth, was swimming at a little distance from a ship, when he saw a shark making towards him. Struck with terror at its approach, he immediately cried out for assistance. A rope was instantly thrown, but, even while the men were in the act of drawing him up the ship's side, the monster darted after him, and at a single snap took off his leg.

Fortunately for the friends of sea-bathing on our shores, the white shark, like his relation, the monstrous Hammer-headed Zygæna, appears but seldom in the colder latitudes, though both have occasionally been found on the British coast.

The northern ocean has got its peculiar sharks, but they are generally either good-natured like the huge basking shark (*S. maximus*), which feeds on sea-weeds and medusæ, or else like the *Picked* dog-fish (*Galeus acanthius*), of too small a size to be dangerous to man, in spite of the ferocity of their nature.

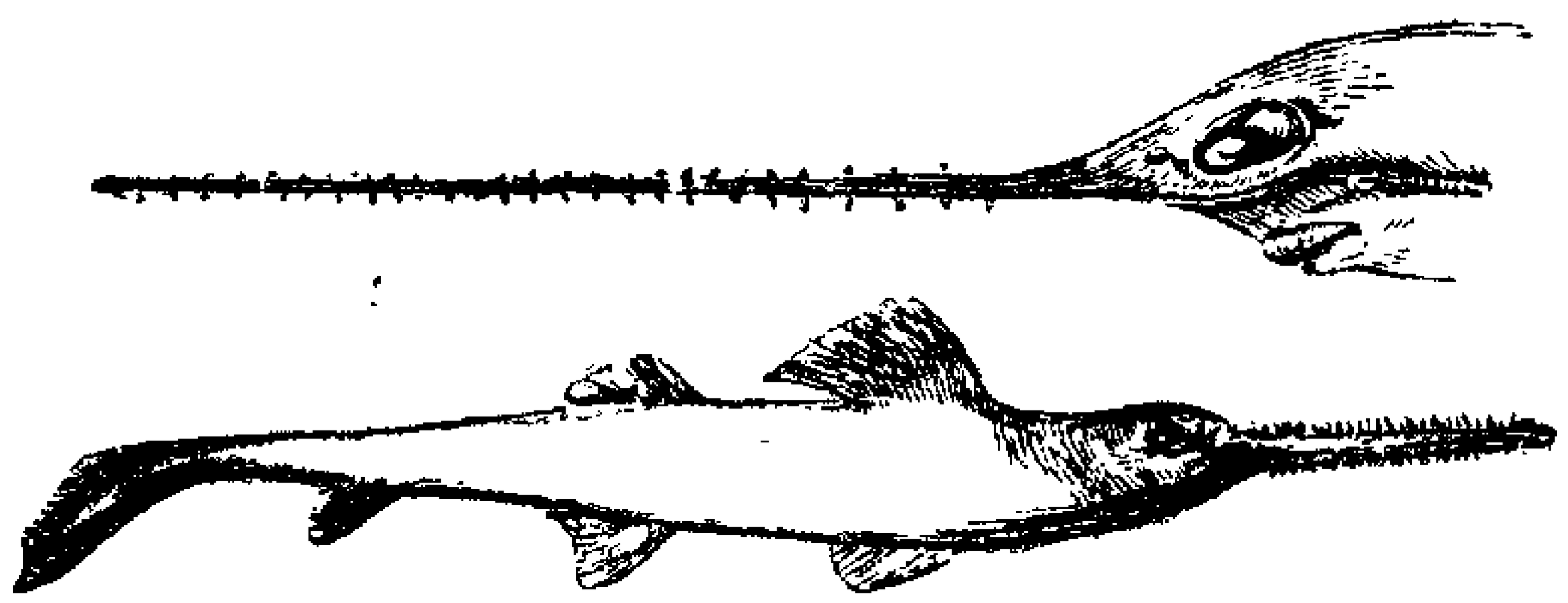

Picked Dog-Fish.

But the dog-fish and several other species of our seas, such as the Blue Shark (*Carcharias glaucus*), though they do not attempt the fisherman's life, are extremely troublesome and injurious to him, by hovering about his boat and cutting the hooks from the lines in rapid succession. This, indeed, often leads to their own destruction, but when their teeth do not deliver them from their difficulty, the blue sharks, which hover about the Cornish coast during the pilchard season, have a singular method of proceeding, which is, by rolling the body round so as to twine the line about them throughout its whole length; and sometimes this is done in such a complicated manner, that Mr. Yarrell has known a fisherman give up any attempt to unroll it as a hopeless task. To the pilchard drift-net this shark is a still more dangerous enemy, and it is common for it to pass in succession along the


Blue-Shark.

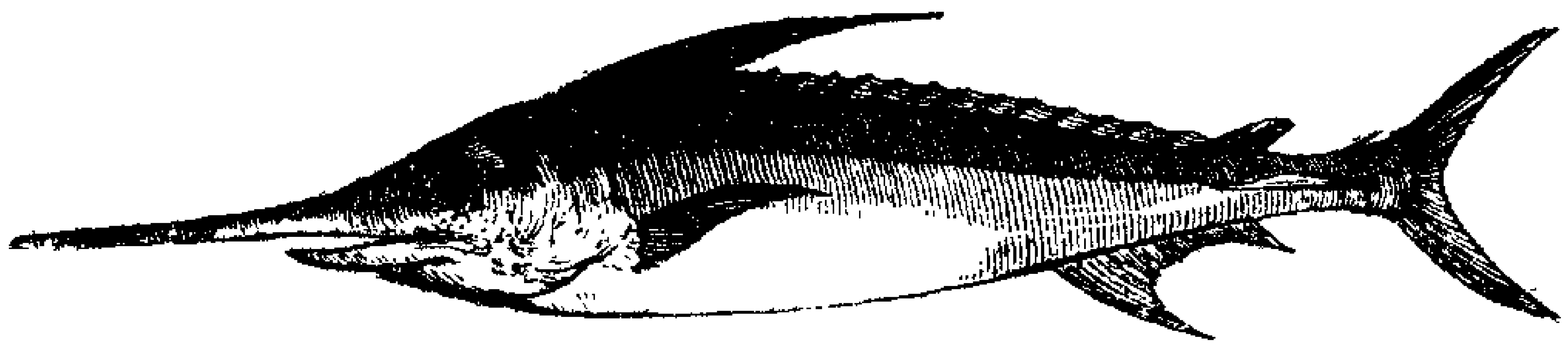
whole length of net, cutting out, as with shears, the fish and the net that holds them, and swallowing both together.

The Saw-snouted Shark or Saw-fish (*Squalus pristis*), which grows to fifteen feet in length, and the Sword-fish (*Xiphias*



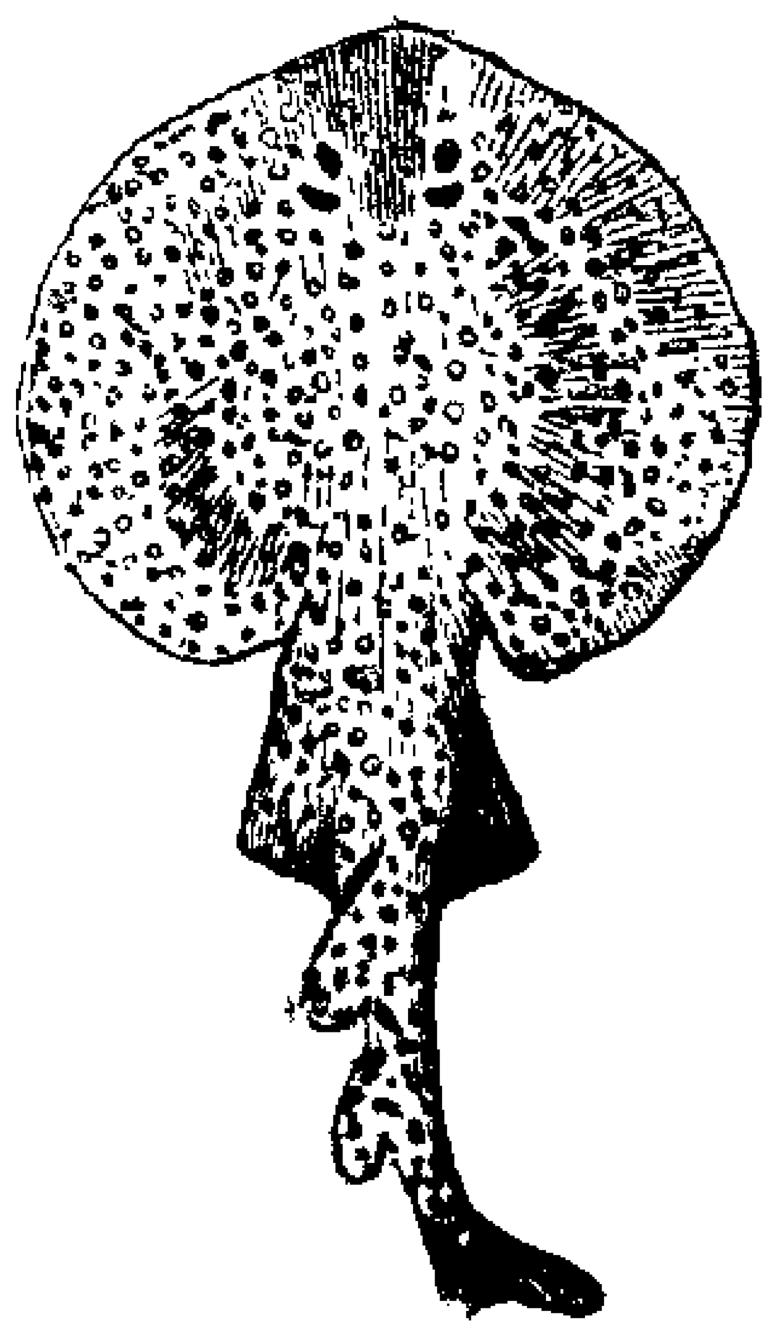
Saw-Fish.

gladius, platypterus), are furnished with peculiarly formidable weapons. The long flat snout of the former is set with teeth on



Sword-Fish.

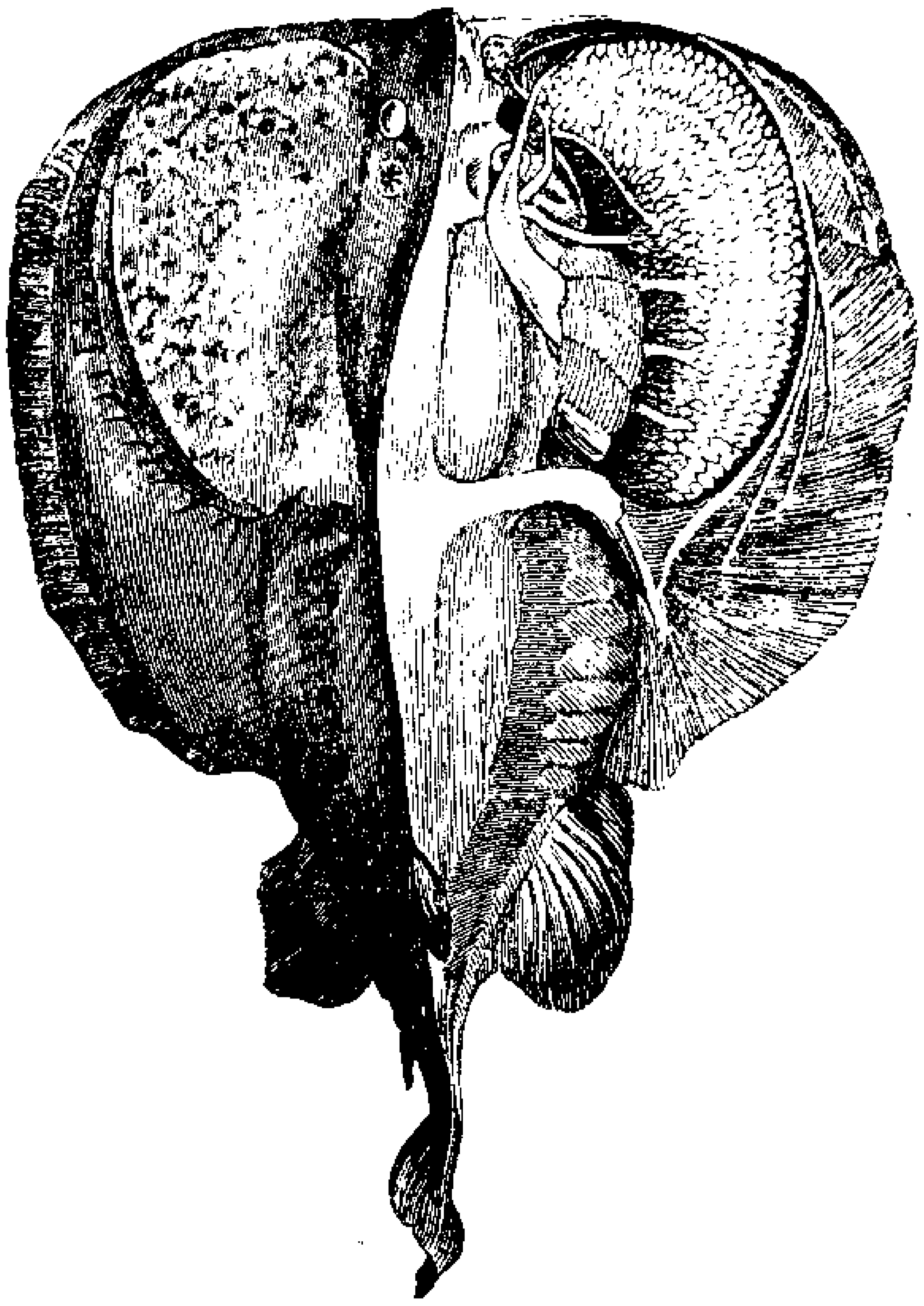
both sides through its whole length, while the upper jaw of the latter terminates in a long sword-shaped snout. A twenty-feet long sword-fish once ran his sword with such violence into the keel of an East Indiaman, that it penetrated up to the root, and the fish itself was killed by the violence of the shock. The perforated beam, with the driven-in sword, are both preserved in the British Museum, and give a good idea of the prodigious power of the leviathans of ocean.



Torpedo.

While most fishes only rely upon their well-armed jaws, their physical strength, or their rapidity, for attack or defence, some of them are provided with more mysterious weapons, and stun their victims or their enemies by electrical discharges.

The Torpedo of the Mediterranean is furnished with wonderful organs for this purpose, situated on each side of the anterior part of the body,—perfect galvanic batteries, consisting of a multitude of small prismatic columns, subdivided into cells, and interwoven with a multitude of nerves, which serve to disengage the electric fluid, and discharge it according to the will of the fish, or when it is excited by some external stimulus. The shock of the torpedo is not so strong as that of the electric-eel (*Gymnotus electricus*) of the Orinoco, which is able to stun a horse, but its power suffices to paralyse the arm of a man. A Sly, or Silurus, found in the Nile or Senegal, and called by the Arabs *raasch*, or lightning, and one of the many Tetrodons inhabiting the tropical seas, is endowed with a similar faculty of producing galvanic shocks.



Muscles and Electric Batteries of the Torpedo.

Some fishes, to whom nature has denied all other offensive weapons, have recourse to stratagem for procuring their food. Hidden in the mud, the Stargazer (*Uranoscopus scaber*) exposes only the tip of the head, and waving the beards with which its lips are furnished in various directions, decoys the smaller fishes and marine insects, that mistake these organs for worms.

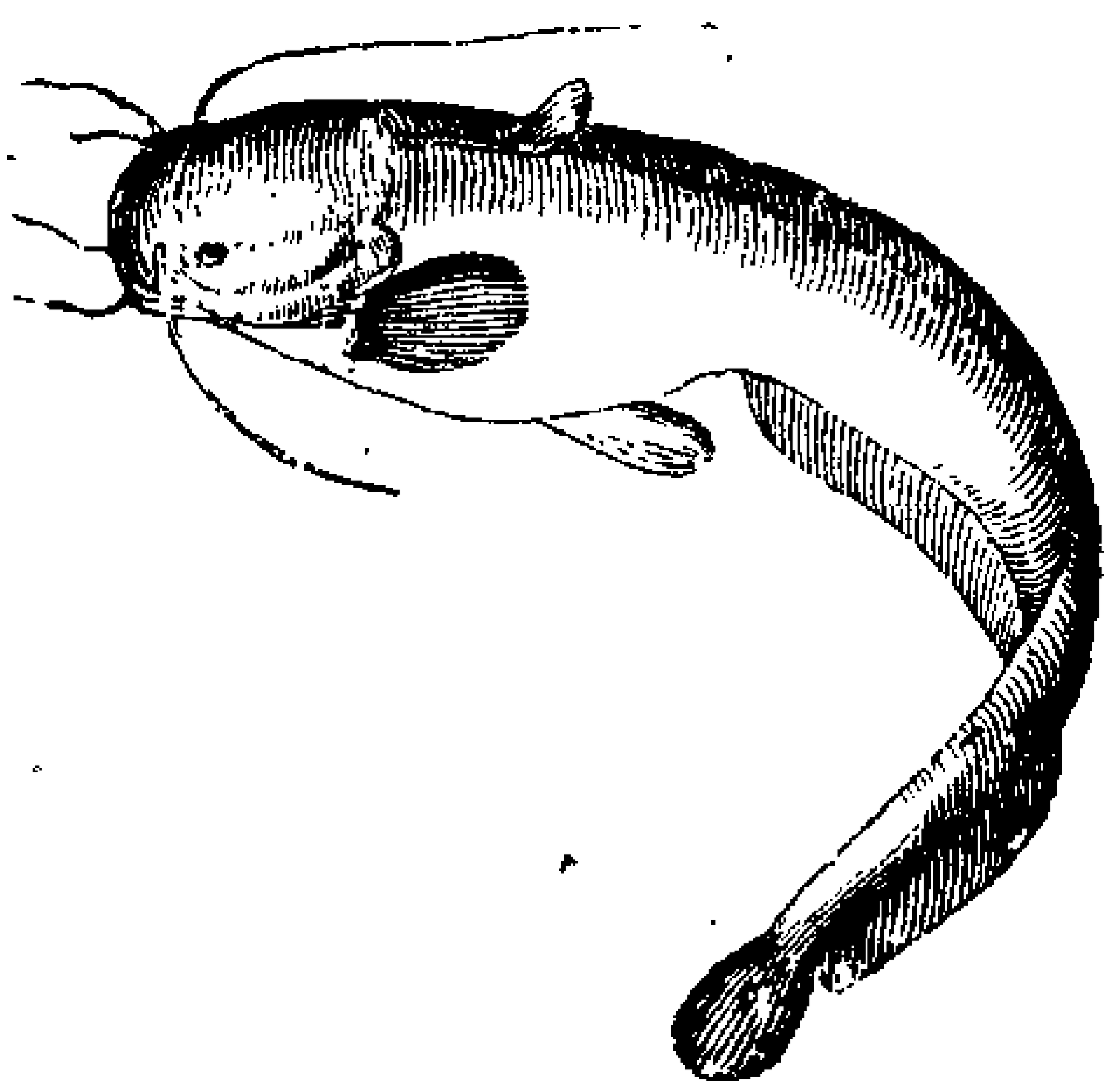
Electric Eel.

The Angler, or Sea-devil (*Lophius piscatorius*), a slow swimmer, who would very often be obliged to fast if he had only his swiftness to rely upon, uses a similar stratagem. Crouching close to the ground, he stirs up the sand or mud, and, hidden by the obscurity thus produced, attracts many a prize by leisurely

moving to and fro the two slender and elongated appendages on his head, the first of which, the better to deceive, is broad and flattened at the end, inviting pursuit by the shining silvery appearance of the dilated part. Even the great European Sly, a fish which has been known to grow to the length of fifteen feet, and to attain a weight of 300 lbs. is not ashamed to owe its food to similar deceits. Like a true lazzarone, the fat creature lies hidden in the mud of rivers, its mouth half open, and angling with its long beards.

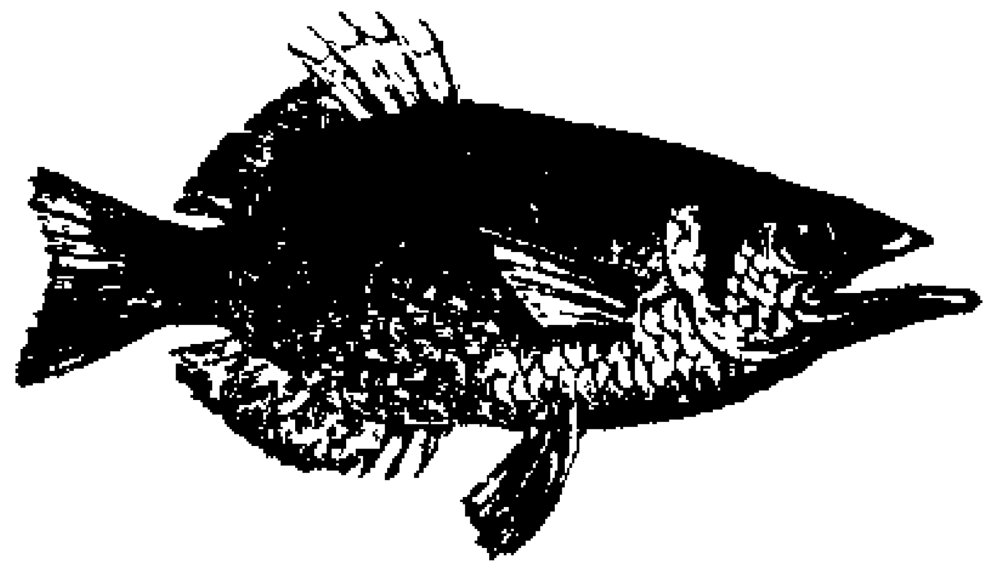
Angler.

But no fish catches its prey in a more remarkable manner than the Beaked, or Rostrated Chætodon, a native of the fresh waters of India. When he sees a fly alighting on any of the plants which overhang the shallow water, he approaches with the utmost caution, coming as perpendicularly as possible under the object of his meditated attack. Then placing himself in an oblique direction, with the mouth and eyes near the surface, he remains a moment immoveable, taking his aim like a first-rate rifleman. Having fixed his eyes directly on the insect, he darts at it a drop of water from his tubular snout, but without showing his mouth above the surface, from which only the drop seems to rise, and that with such effect, that though at the distance of four, five or six feet, it very seldom fails to bring its prey into the water. Another small East Indian fish, the *Toxotes jaculator*, catches its food by a similar dexterous display of archery.



European Sly.—(Silurus glanis.)

While all other fishes hunt only for their own benefit, the Indian Remora, or Sucking-fish (*Echeneis Naucrates*), owes to the remarkable striated apparatus on its head, by which it firmly adheres to any object—rock, ship, or animal,—to which it

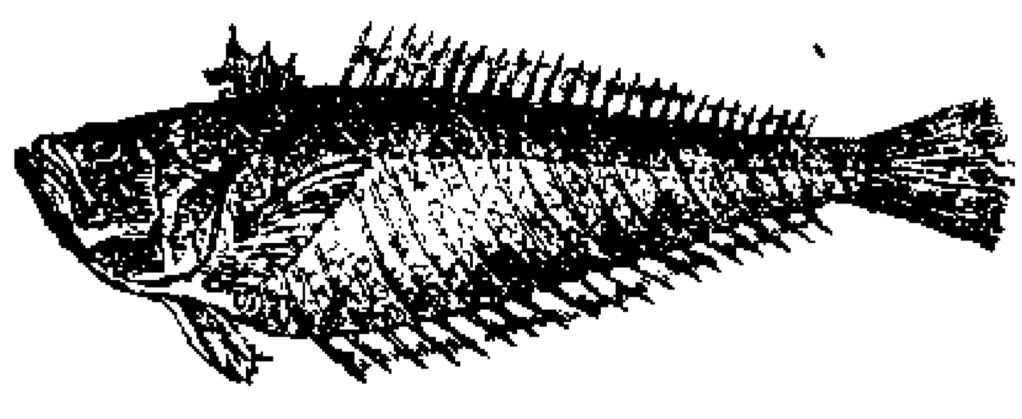


Toxotes Jaculator.

chooses to attach itself, the rare distinction of being employed by man as a hunting-fish. When Columbus first discovered the West Indies, the inhabitants of the coasts of Cuba and Jamaica made use of the remora to catch turtles, by attaching to its tail a strong cord of palm-fibres, which served to drag it out of the water along with its prey. By this means they were able to raise turtles weighing several hundred pounds from the bottom; "for the sucking-fish," says Columbus, "will rather suffer itself to be cut to pieces than let go its hold." In Africa, on the Mozambique coast, a similar method of catching turtles is practised to the present day. Thus a knowledge of the habits of animals, and similar necessities, have given rise to the same hunting artifices among nations that never had the least communication with each other. Everybody knows the fables that have been related of the small Mediterranean remora (*Echeneis remora*). It even owes its Latin name to the marvellous story of its being able to arrest a ship under full sail in the midst of the ocean; and from this imaginary physical power a no less astonishing moral influence was inferred, for the ancients believed that tasting the remora completely subdued the passion of love, and that if a delinquent, wishing to gain time, succeeded in making his judge eat some of its flesh, he was sure of a long delay before the verdict was pronounced.

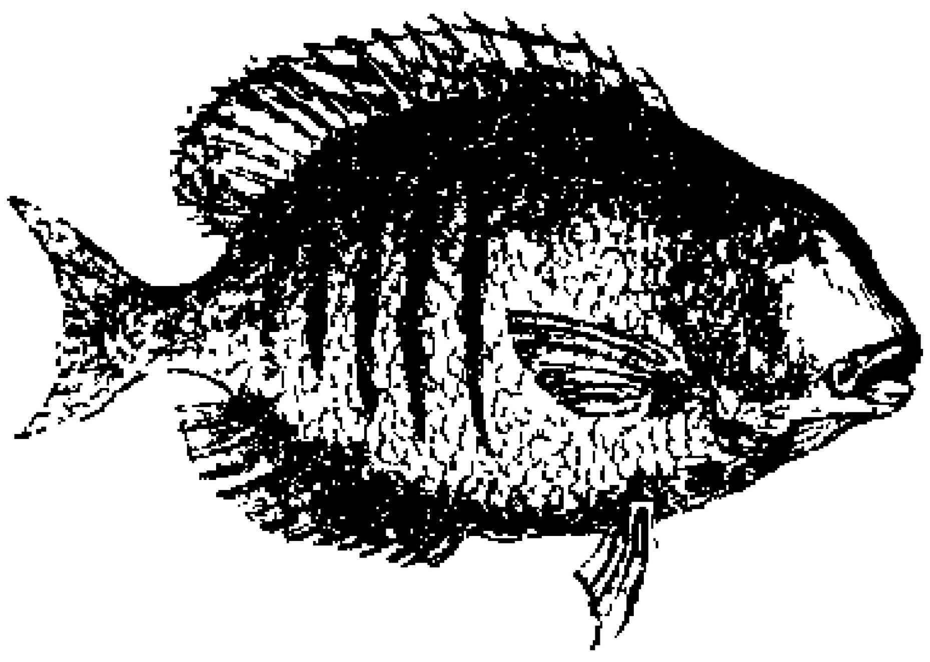
Sucking-fish. (Remora.)

Most fishes have only a rapid flight to depend upon for their safety; some, however, more favoured by nature, have been provided with peculiar defensive weapons. Thus the dorsal fins of the Dragon-weever (*Trachinus draco*), a small silvery fish, frequently occurring on our shores, are armed with strong spines, that effectually provide against its being easily swallowed by a more powerful enemy. The wounds it inflicts are very troublesome and painful, though it does not appear that the spines contain any poisonous matter, as the fishermen generally believe. At all events, the dragon-weever is not nearly so dangerous as the *Clip*



Common Weever.

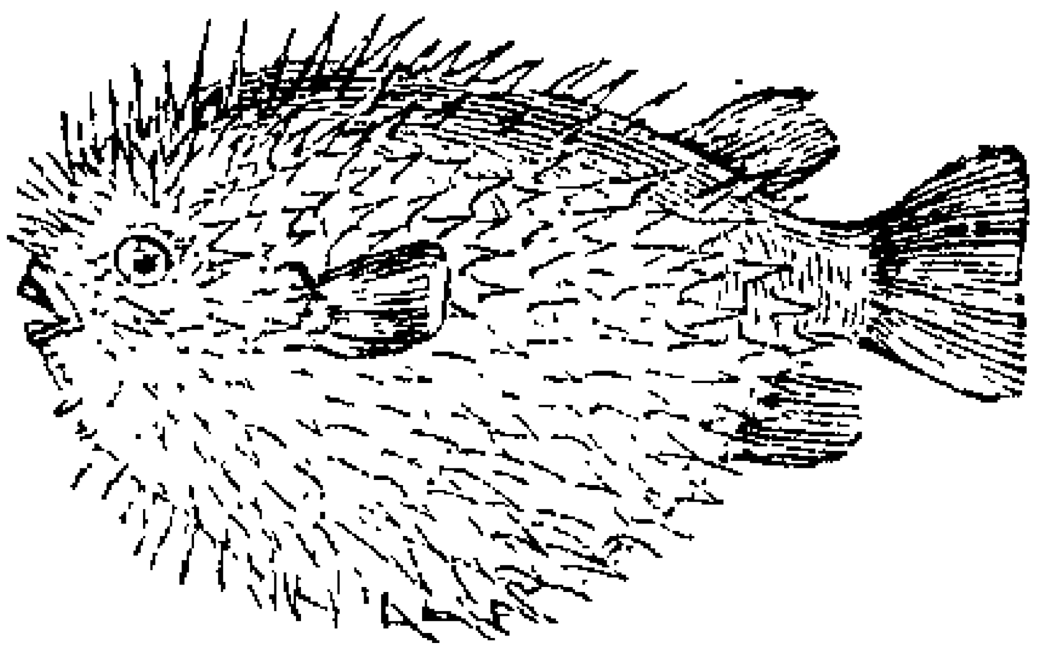
bagre, a kind of silurus or sly, inhabiting the Brazilian rivers, that inflicts with its long spines such painful wounds as to deprive the sufferer of consciousness, and to produce an inflammation that lasts for several weeks. The Lance-tails, or Acanthuri, have a sharp bony process, not unlike the very large thorn of a rose-tree, placed on each side of the tail; by this they can inflict a deep cut on the hand of any one who is so imprudent as to seize them in that part.



Surgeon Fish. (Acanthurus.)

I could still add a long list of spine-armed fishes, but content myself with noticing the Stickleback, which frequently owes its preservation to the sharp needles with which it is provided.

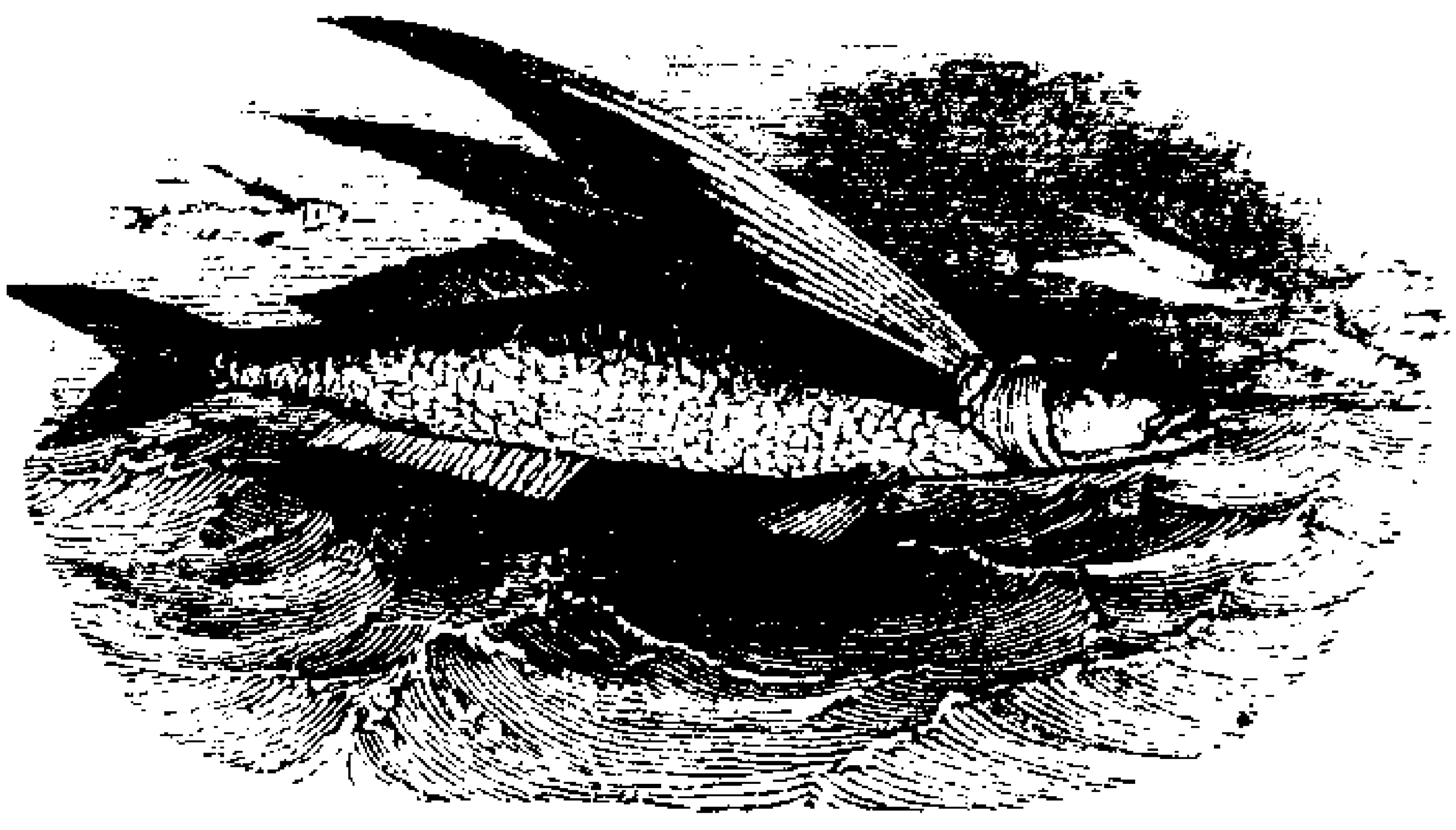
The Tetrodons and Diodons have the power of inflating their body at pleasure, and thus raising the small spines dispersed over their sides and abdomen in such a manner, as to operate as a defence against their enemies. These beautiful and remarkable fishes chiefly inhabit the tropical waters, but sometimes wander into higher latitudes. Man is not the only creature driven by the currents of fate far from the place of his birth.



Diodon.

The Flying-fishes (*Exoceti*) are provided with pectoral fins of so great a length, as to be able to carry them, like wings, a great distance through the air. According to Mr. George Bennett ("Wanderings in New South Wales"), they cannot raise themselves when in the atmosphere, the elevation they take depending entirely on the power of the first spring or leap they make on leaving their native element. Their flight, as it is called, carries them fifteen or eighteen feet high over the water, and the lines which they traverse when they enjoy full liberty of motion, are very low curves, and always in the direction of their previous progress in the usual element of fishes. Their silvery wings and blue bodies glittering beneath the rays of a tropical sun, afford a most beautiful spectacle, when, as is frequently the case, they rise into the air by thousands at once, and in all possible directions. The advantage afforded them by their wing-like fins, in

escaping from the pursuit of the bonitos and albacores, often, however, leads to their destruction in another element, where gulls and frigate-birds frequently seize them with lightning-like rapidity, ere they fall back again into the ocean. It is amusing to observe a bonito swimming beneath the feeble aëronaut, keeping him steadily in view, and preparing to seize him at the moment of his descent. But the flying-fish often eludes the bite of his enemy, by instantaneously renewing his leap, and not unfrequently escapes by extreme agility.



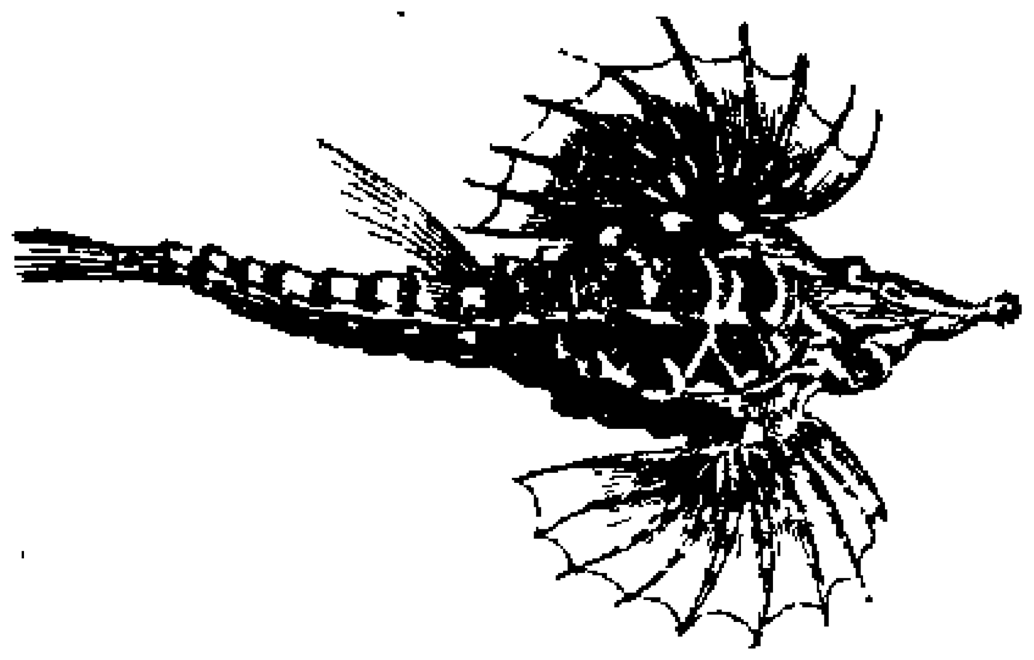
Flying Fish.

The specific gravity of the flying-fish can be most admirably regulated in correspondence with the element through which it may move. The swim-bladder, when distended, occupies nearly the entire cavity of the abdomen, thus containing a large volume of air; and in addition to this, there is a membrane in the mouth which can be inflated through the gills. The pectoral fins, though so large when expanded, can be folded into an exceedingly slender, neat, and compact form, so as to be no hindrance to swimming. A light displayed from the chains of a vessel in a dark night, will bring many flying-fishes on board, where they are esteemed as a great delicacy. Their fate, thus to be persecuted in both elements and to find security nowhere, has often been pitied in prose and verse; but although they excite so much sentimental commiseration, they are themselves no less predaceous than their enemies, feeding chiefly on smaller fishes.

The flying-fish of the West Indian waters is frequently allured by the tepid waters of the Gulf-stream into higher latitudes, and Pennant cites several examples of its having been found near the British coast.

The Flying-Gurnard (*Trigla volitans*) of the Mediterranean, Atlantic, and Indian seas, a highly singular and beautiful species, also raises itself into the air by means of its large pectoral fins,

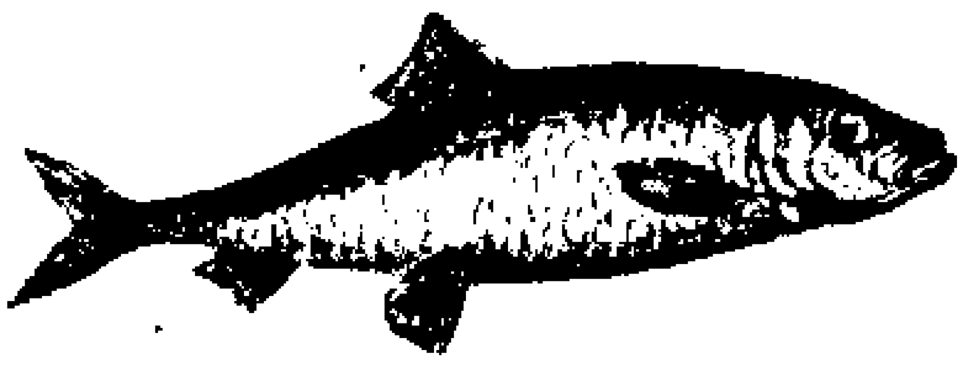
It does not fly very high, but swings itself as far as a musket-ball reaches, and may thus elude even the rapidity of the dolphin. That strangely formed fish, the *Pegasus* of the Indian seas, is also enabled by its large pectoral fins to support itself for some moments in the air, when it springs over the surface of the water.



Swimming Pegasus.

Neither the quadrupeds nor the birds are subject to so many persecutions as the fishes, which have inexorable enemies in all classes of animals. Numberless molluscs and zoophytes feed upon their eggs, or devour their minute fry; myriads of sea-birds are on the look-out for them along the strands, or on the high ocean; seals and ice-bears lie in wait for them, while with weapons and deceit, with net, angle and harpoon, man carries death and destruction into their ranks. It would be a difficult task to state with any degree of exactness the number of fishermen disseminated over the face of the globe, but if we consider that, on a moderate calculation, at least a million of persons are directly or indirectly engaged in fishing in Great Britain and Ireland alone, and then cast a glance over the immense coast-line of the ocean, we may without exaggeration affirm that at least one-fiftieth part of the human race lives upon the produce of the seas. If we further reflect that fishes form a great part of the food of all coast-inhabitants, and consider in what masses they are sent into the interior,—fresh, dried, salted, smoked, and pickled,—we cannot doubt that the great extent of the ocean only apparently limits the numbers of the human race, for how many thousands of square miles of the most fruitful soil would it not require to bring forth the quantity of food which the blue and green fields of ocean supply to man? "Bounteous mother," "*Alma parens*," was the name given by the grateful ancients to the corn and grass-producing, herd-feeding earth; but how much more deserving of that endearing appellation is the sea, that, without being ploughed or manured, dispenses her gifts with such inexhaustible profusion! Numberless indeed are the various kinds of fishes which she furnishes to man, for almost every species affords an equally agreeable and healthy food: but of all the finny families or tribes that people the ocean none can

compare for utility with that of the *Clupeidæ*, or Herrings, small in size but great in importance. In mile-long shoals, often so thickly pressed that a spear cast into them would stand upright in the living stream, the common herring appears annually on the coasts of north-western Europe, pouring out the horn of abundance into all the lochs, bays, coves, and fiords, from Norway to Ireland, and from Orcadia to Normandy. Sea-birds without end keep thinning their ranks during the whole summer; armies of rorquals, dolphins, seals, shell-fish, cods, and sharks devour them by millions, and yet so countless are their numbers, that whole nations live upon their spoils.



Herring.

As soon as the season of their approach appears, fleets of herring boats leave the northern ports, provided with drift-nets, about 1200 feet long. The yarn is so thick that the wetted net sinks through its own weight, and need not be held down by stones attached to the lower edge, for it has been found that the herring is more easily caught in a slack net. The upper edge is suspended from the drift-rope by various shorter and smaller ropes, called buoy ropes, to which empty barrels are fastened, and the whole of the floating apparatus is attached by long ropes to the ship. Fishing takes place only during the night, for it is found that the fish strike the nets in much greater numbers when it is dark than while it is light. The darkest nights, therefore, and particularly those in which the surface of the water is ruffled by a fresh breeze, are considered the most favourable. To avoid collisions, each boat is furnished with one or two torches. From off the beach at Yarmouth, where often several thousand boats are fishing at the same time, these numberless lights, passing to and fro in every direction, afford a most lively and brilliant spectacle. The meshes of the net are exactly calculated for the size of the herring, wide enough to receive the head as far as behind the gill-cover, but not so narrow as to allow the pectoral fins to pass. Thus the poor fish, when once entangled, is unable to move backwards or forwards, and remains sticking in the net, like a bad logician on the horns of a dilemma, until the fisherman hauls it on board. In this manner a single net sometimes contains so vast a booty, that it requires all the authority of a Cuvier or a Valenciennes to make us believe the

instances they mention. A fisherman of Dieppe caught in one night 280,000 herrings, and threw as many back again into the sea. Sometimes great sloops have been obliged to cut their nets, being about to sink under the superabundant weight of the fish.

The oldest mention of the herring-fishery is found in the chronicles of the monastery of Evesham, of the year 709; while the first French documents on the subject only reach as far as the year 1030. As far back as the days of William the Conqueror, Yarmouth was renowned for its herring-fishery; and Dunkirk and the Brill conducted it on a grand scale centuries before William Beukelaer of Biervliet, near Sluys, introduced a better method of pickling herrings in small kegs, instead of salting them as before in loose irregular heaps. It is very doubtful whether Solon or Lycurgus ever were such benefactors of their respective countries as this simple uneducated fisherman has been to his native land; for the pickled herring mainly contributed to transform a small and insignificant people into a mighty nation. In the year 1603, the value of the herrings exported from Holland amounted to twenty millions of florins; and in 1615, the fishery gave employment to 2000 *buysen*, or smacks, and to 37,000 men. Three years later we see the United Provinces cover the sea with 3000 *buysen;* 9000 additional boats served for the transport of the fishes, and the whole trade gave employment to at least 200,000 individuals. At that time Holland provided all Europe with herrings, and it may without exaggeration be affirmed that this small fish was their best ally and assistant in casting off the Spanish yoke, by providing them with money, the chief sinew of war. Had the emperor Charles V. been able to foresee that Beukelaer's discovery would one day prove so detrimental to his son and successor Philip II., he would hardly have done the poor fisherman the honour to eat a herring and drink a glass of wine over his tomb.

But all human prosperity is subject to change; and thus towards the middle of the sixteenth century a series of calamities ruined the Dutch fisheries. Cromwell gave them the first blow by the Navigation Act; Blake the second, by his victories; in 1703 a French squadron destroyed the greatest part of their herring-smacks; and finally, the competition of the Swedes, and the closing of their ports by the English, under the disastrous domination of Napoleon I., completed the ruin of

that branch of trade which had chiefly raised the fortunes of their fathers.

In the year 1814, when the Dutch first began to breathe after having shaken off the yoke of the modern Attila, they made a faint attempt to renew the herring-fishery with 106 boats, which, up to the year 1823, had only increased to 128; since 1836, however, there has been a steady progress, and herring-catching in the Zuyder Zee during the winter months is yearly increasing in importance.

During the second half of the last century, while the herrings began to desert the Dutch nets, they enriched the Swedes, who, during the year 1781, exported from Gottenburg alone 136,649 barrels, each of them containing 1200 herrings. But some years after, the shoals on the Swedish coasts began also to diminish, so that in 1799 there was hardly enough for home consumption. And now commenced the rapid rise and increase of the Scotch herring-fisheries; and it is certainly remarkable that this should have taken place at so late a period, since the British waters are perhaps those which most abound in herrings. When we think of the present grandeur of British commerce, which extends to the most distant parts of the globe, and ransacks all Nature for new articles of trade, it seems almost incredible that up to the middle of the sixteenth century the herring-fishery on the British coasts was left in the hands of the Dutch and Spaniards, and that the acute and industrious Scotchmen should have been so tardy in working the rich goldmines lying at their gates. But if their appearance in the market has been late, they have made up for lost time, by completely distancing all their competitors. In 1855, the Scotch herring-fisheries employed no less than 11,000 smacks or boats, manned by 40,000 seamen, who were assisted by 28,000 curers and labourers, exclusive of the vessels and men bringing salt and barrels or engaged in carrying on the export trade.

The English herring-fishery is also extremely important, for Yarmouth alone employs in this branch of trade about 400 sloops, of from forty to seventy tons, the largest of which have ten or twelve men on board. Three of these sloops, belonging to the same proprietor, landed, in the year 1857, 285 lasts, or 3,762,000 fishes; and as each last was sold for £14 sterling, it is

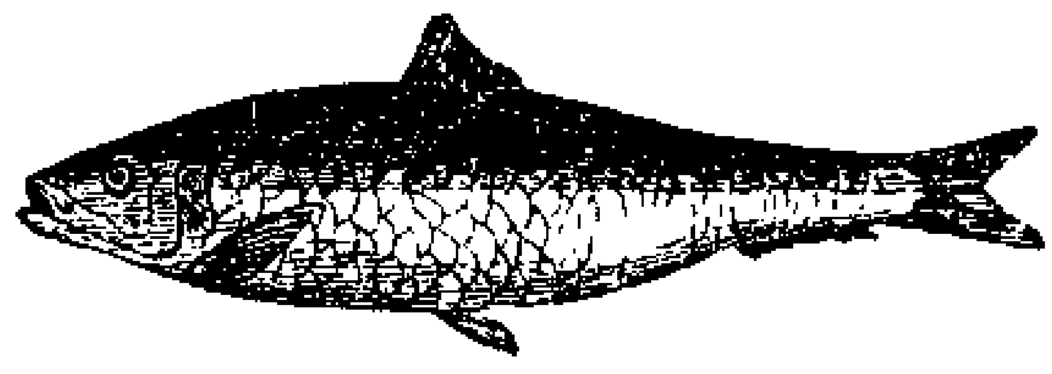
probable that no whaler made a better business that season. The importance of the Yarmouth herring-fishery may be inferred from the fact, that it gives employment and bread to about 5,000 persons during several months of the year, and engages a capital of at least £700,000. No wonder, that among the north seamen the herring-fishery is called the "great" fishery, while that of the whale is denominated only the "small."

But the herring is a very capricious creature, seldom remaining long in one place; and there is not a station along the British coast which is not liable to great changes in its visits, as well with regard to time as to quantity. The real causes of these irregularities are unknown; the firing of guns, the manufacture of kelp, and the paddling of steam-boats have been assigned as reasons, but such reasons are quite imaginary. The progress of science promises to find, however, a remedy even for the caprices of the herring; and if his shoals frequently appear and disappear again in the more retired bays or fiords of Norway, before the fishermen are apprised of his movements, the electric telegraph (the most wonderful discovery of a time so rich in wonderful inventions), will be used for his more effectual capture. By this time the wires are already laid, which are to communicate along the whole Scandinavian coast, and with the rapidity of lightning, every important movement of the marine hosts. Poor herring! who would have thought, when Franklin made his first experiments upon electricity, that that mysterious power should ever be used for thy destruction!

The supposed migration of herrings to and from the high northern latitudes is not founded on fact; the herring has never been seen in abundance in the northern seas, nor have our whale-fishers or Arctic voyagers taken any particular notice of them There is no fishery for them of any consequence either in Greenland or Iceland. On the southern coast of Greenland the herring is a rare fish, and, according to Crantz, only a small variety makes its appearance on the northern shore. This small variety, or species, was found by Sir John Franklin on the shore of the Polar basin, on his second journey. There can be no doubt that the herring inhabits the deep water all round our coast, and only approaches the shores for the purpose of depositing its spawn within the immediate influence of the two principal agents in vivification—increased temperature and oxygen—and

as soon as that essential object is effected, the shoals that haunt the superficial waters disappear, but individuals are found, and many are to be caught throughout the year. So far are they from being migratory to us from the north only, that they visit the west coast of Cork in August, arriving there much earlier than those which come down the Irish Channel, and long before their brethren make their appearance at places much farther north. Our common herring spawns towards the end of October, or the beginning of November, and it is for two or three months previous to this, when they assemble in immense numbers, that the fishing is carried on, which is of such great and national importance. "And here," Mr. Couch observes, "we cannot but admire the economy of Divine Providence, by which this and several other species of fish are brought to the shores, within reach of man, at the time when they are in their highest perfection and best fitted to be his food." The herring having spawned, retires to deep water, and the fishing ends for that season. While inhabiting the depths of the ocean, its food is said, by Dr. Knox, to consist principally of minute entomostraceous animals, but it is certainly less choice in its selection when near the shore.

Although the common herring of our northern seas is beyond all doubt the most important of the tribe, yet there is no sea, no coast, where other species of the same family are not a source of abundance to man, and of astonishment by their vast numbers. Thus the enormous shoals of Pilchards appearing along our south-western coasts are not less valuable to the fishermen of Devon and Cornwall than the common herring to those of the North Sea. The older naturalists considered the pilchard, like the herring, as a visitor from a distant region, and they assigned to it also the same place of resort as that fish, with which indeed the pilchard has been sometimes confounded. To this it will be a sufficient reply, that the pilchard is never seen in the Northern Ocean. They frequent the French coasts, and are seen on those of Spain, but on neither in considerable numbers or with much regularity; so that few fishes confine themselves within such narrow bounds. On the coast of Cornwall they are found throughout all the



Pilchard.

seasons of the year, and even there their habits vary in the different months. In January they keep near the bottom, and are chiefly hauled up in the stomachs of ravenous fishes; in March they sometimes assemble in *schulls*, but this union is only partial and not permanent and only becomes so in July; when they regularly and permanently congregate so as to invite the fisherman's pursuit. The season and situation for spawning, and the choice of food, are the chief reasons which influence the motions of the great bodies of these fish; and it is probable that a thorough knowledge of these particulars would explain all the variations which have been noticed in the doings of the pilchard, in the numerous unsuccessful seasons of the fishery.

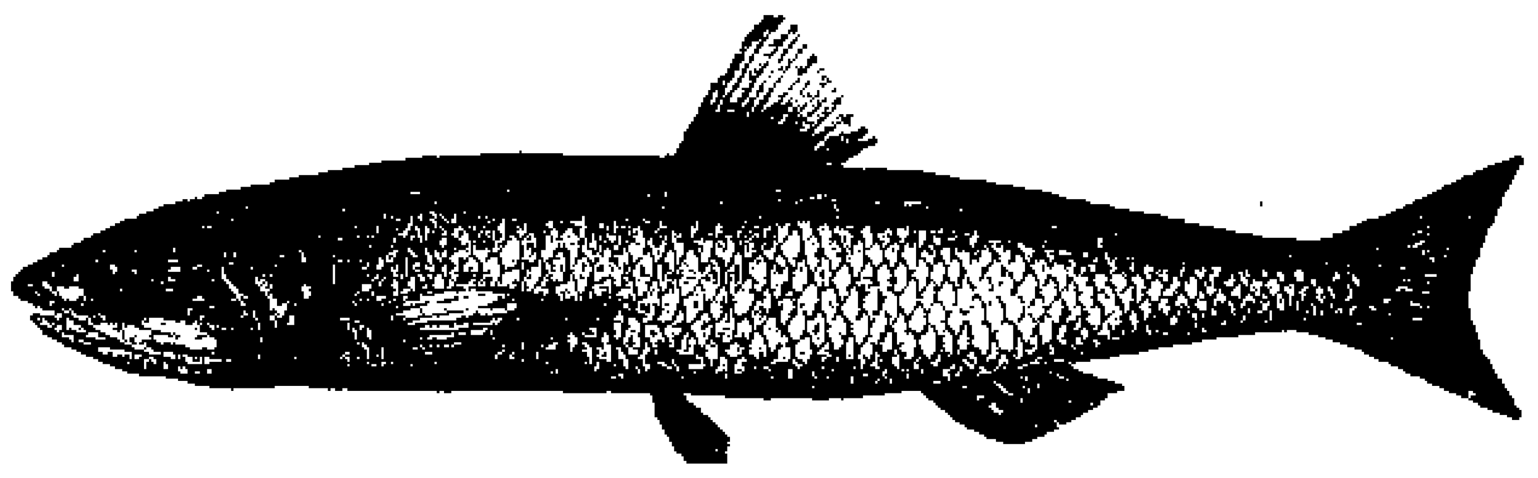
They feed with voracity on small crustaceous animals, and Mr. Yarrell frequently found their stomachs crammed with thousands of a minute species of shrimp, not larger than a flea. It is probably when they are in search of something like this, that fishermen report they have seen them lying in myriads quietly at the bottom, examining with their mouths the sand and small stones in shallow water. The abundance of this food must be enormous, to satisfy such a host.

"When near the coast," says the author of the "History of British Fishes," "the assemblage of pilchards assumes the arrangement of a mighty army, with its wings stretching parallel to the land, and the whole is composed of numberless smaller bodies, which are perpetually joining together, shifting their position, and separating again. There are three stations occupied by this great body, that have their separate influence on the success of the fishery. One is to the eastward of the Lizard, the most eastern extremity, reaching to the Bay of Bigbury in Devonshire, beyond which no fishing is carried on, except that it occasionally extends to Dartmouth; a second station is included between the Lizard and Land's End; and the third is on the north coast of the county, the chief station being about St. Ives. The subordinate motions of the shoals are much regulated by the tide, against the current of which they are rarely known to go, and the whole will sometimes remain parallel to the coast for several weeks, at the distance of a few leagues; and then, as if by general consent, they will advance close to the shore, sometimes without being discovered till they have reached it. This usually happens when the tides are strongest, and is the period when

the principal opportunity is afforded for the prosecution of the sean-fishery." The quantity of pilchards taken is sometimes incredibly large. In 1847, a very productive year, 40,000 hogsheads were cured in Cornwall alone, representing probably, after all deductions, a net value to the takers of £80,000. The Sardine (*Clupea sardina*), a fish closely allied to the Pilchard though smaller, is considered as the most savoury of all the herring tribe. It is chiefly found in the Mediterranean, on the coasts of South France and Africa, and about the islands of Corsica and Sardinia, where it plays a no less important part than the Pilchard on the coasts of Cornwall and Devonshire.

Though a much less valuable fish than its larger-sized relatives, the diminutive Sprat is not to be despised. Coming into the market in immense quantities, and at a very moderate price, immediately after the herring season is over, it affords during all the winter months a cheap and agreeable food. Like all other species of the herring tribe, the sprats are capricious wanderers, and make their appearance in exceedingly variable numbers. The coasts of Kent, Essex, and Suffolk, are the most productive. So great is the supply thence obtained, that notwithstanding the immense quantity consumed by the vast population of London and its neighbourhood, there is yet occasionally a surplus to be disposed of at so low a price, as to induce the farmers, even so near the metropolis as Dartford, to use them for manure.

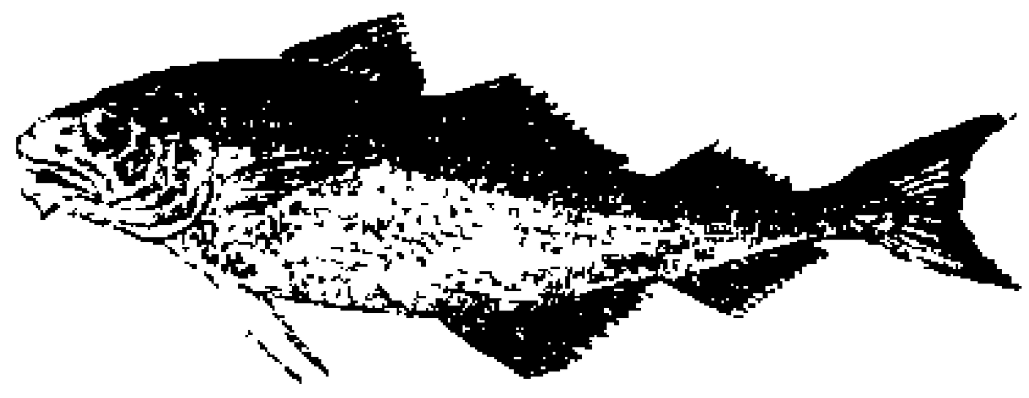
The Mediterranean seems to be the peculiar birthplace of the Anchovy (*Engraulis encrasicholus*), where it appears in the spawning season in countless multitudes along the shallow coasts. It is about four inches long, of a bluish-brown colour on the back, and silvery-white on the belly. It is covered with large thin and easily deciduous scales, and may be readily distinguished from the Sprat and other kindred species by the anal fins being remarkably short. It is mostly caught in the neighbourhood of Antibes, Frejus, and St. Tropez, and sent pickled in enormous quantities



Anchovy.

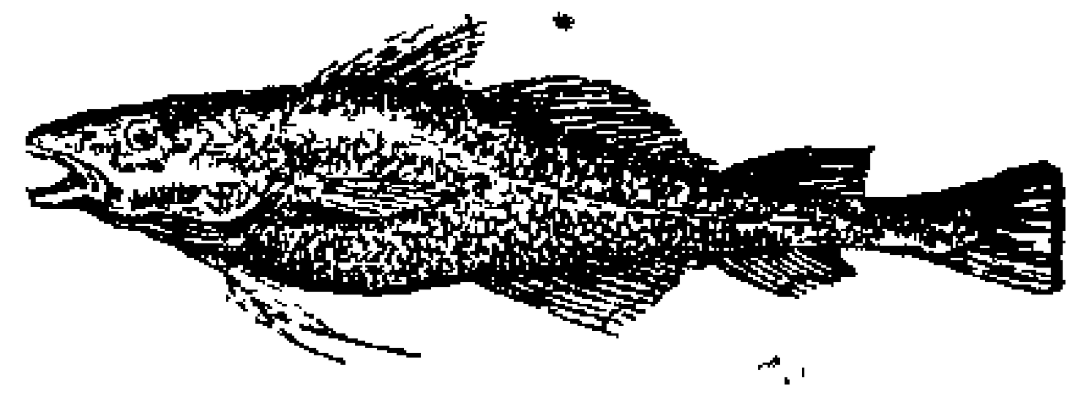
to the fair of Beaucaire, from whence it is transported in small tin boxes to all parts of the world.

The Cod-family, to which among others, the Dorse, the Haddock, the Whiting, the Hake, the Ling, and other valuable fishes belong, ranks next to that of the herrings in importance to man. In the seas with which Europeans are best acquainted the common Cod, the chief representative of the tribe, is found universally, from Iceland to very nearly as far south as Gibraltar, but appears most abundantly on the eastern side of the American continent, and among its numerous islands, from 40° up to 66° N. lat., where it may be said to hold dominion from the outer edge of the great banks of Newfoundland, which are more than three hundred miles from land, to the verge of every creek and cove of the bounding coast. To support such a mass of living beings, the ocean sends forth its periodical masses of other living beings. At one season the cod is accompanied by countless myriads of the Capelin (*Salmo arcticus*), and at another by equal hosts of a molluscous animal, the Cuttle-fish (*Sepia loligo*), called in Newfoundland the squid. The three animals are migratory, and man, who stations himself on the shore for their combined destruction, conducts his movements according to their migrations, capturing millions upon millions of capelins and squids, to serve as a bait for the capture of millions of cods. In the United Kingdom alone this fish, in the catching, the curing, the partial consumption, and sale, supplies employment, food, and profit to thousands of the human race; but the banks of Newfoundland are the chief scene of its destruction. As soon as spring appears, England sends forth 2000 ships, with 30,000 men, across the Atlantic, towards those teeming shallows; France about one-half the number; and the Americans as many as both together. On an average, each ship is reckoned to catch about 40,000 fishes; and we may form some idea of the voracity, as



Haddock.

Ling.



Cod.

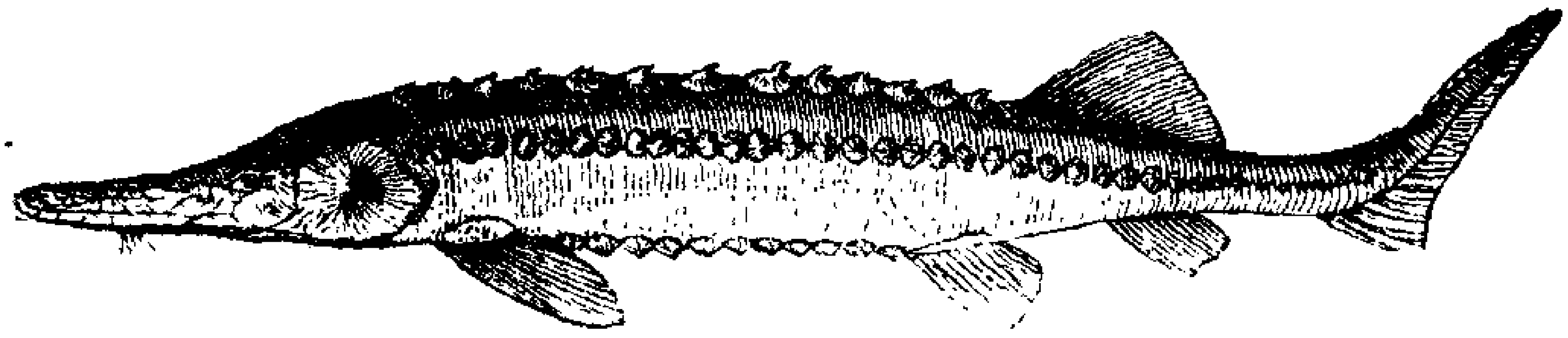
well as of the numbers of the cod, when we hear that in the course of a single day a good fisherman is able to haul up four hundred one after another with his line—no easy task considering the size of the fish, which often attains a length of from two to three feet and a weight of from twenty to forty pounds.

The captured fish have but little time left them to bewail their lot, for a few thousands will be "dressed down"—that is, gutted, boned and salted—in the course of two or three hours. For this purpose the crew divide themselves into throaters, headers, splitters, salters, and packers. First the throater passes his sharp knife across the throat of the unfortunate cod to the bone and rips open the bowels. He then passes it quickly to the header, who with a strong sudden wrench pulls off the head and tears out the entrails, which he casts overboard, passing at the same time the fish instantly to the splitter, who with one cut lays it open from head to tail, and almost in the twinkling of an eye with another cut takes out the backbone. After separating the sounds, which are placed with the tongues, and packed in barrels as a great delicacy, the backbone follows the entrails overboard, while the fish at the same moment is passed with the other hand to the salter. Such is the amazing quickness of the operations of heading and splitting that a good workman will often decapitate and take out the entrails and back-bone of six fish in a minute. Every fisherman is supposed to know something of each of these operations, and no rivals at cricket ever entered with more ardour into their work than do some athletic champions for the palm of "dressing down" after a "day's catch."

Besides its excellent firm flesh, the liver-oil of the cod is used as a valuable medicine, and serves to restore many a scrofulous or rickety child to health. The sound-bladder is also employed by the Icelanders for the manufacture of fish-lime or isinglass. The best quality of the latter article, however, is afforded by a species of Sturgeon (*Accipenser Huso*) which is chiefly found in the Black and Caspian seas, and ascends the tributary rivers in immense numbers.

The Common Sturgeon (*Accipenser sturio*), though principally frequenting the seas and rivers of North-Eastern Europe, where, especially in the Volga, extensive fisheries are established for its

destruction, is also captured on the coasts of Great Britain and Ireland, as examples are by no means uncommon in the fishmongers' shops of our great cities, a few coming into the hands of the principal dealers every season. Yarrell mentions one caught in a stake-net near Findhorn, in Scotland, in July 1833,



Common Sturgeon.

which measured eight feet six inches in length and weighed two hundred and three pounds; but in the Baltic specimens of a length of eighteen feet and weighing a thousand pounds have occasionally been captured. The body is long and slender from the shoulders backward, somewhat pentagonal in shape, with five longitudinal rows of flattened plates, with pointed central spines, directed backwards, and the snout is tapering and beak-shaped, the mouth small and toothless, so that the sturgeon, though almost equalling the white shark in size, is of a much more harmless character and formidable only to the crustaceans, small fish, or soft animals, he meets with at the bottom in deep water, beyond the ordinary reach of sea-nets. Hence he is rarely caught in the open sea, but falls an easy prey to the cunning of man when entering the friths, estuaries, and rivers for the purpose of spawning. The sturgeon is a highly valuable fish not only for its well-flavoured flesh but also for its roe, which furnishes the delicate caviar of commerce. The smallest but most highly esteemed of the sturgeons is the Sterlet of the Volga, which sometimes fetches such extravagant prices that Prince Potemkin has been known to pay three hundred roubles for a single tureen of sterlet-soup.

While many of the numerous members of the salmon family confine themselves to the rivulet or to the lake, others alternate, like the sturgeons, between the river and the sea. Of these the most remarkable is the noble fish which has given its name to the whole tribe, and may justly be considered as its head, not only in point of size but also for its wide-spread utility to man.

Every spring or summer the salmon leave the ocean to deposit their spawn in the sweet waters, often at a distance of many hundred miles in the interior of the Continent, so that the same fish which during part of the year may be breasting the waves of the North Sea, may at another be forcing the current of an Alpine stream. Their onward progress is not easily stopped: they shoot up rapids with the velocity of arrows, and make wonderful efforts to surmount cascades or weirs by leaping, frequently clearing an elevation of eight or ten feet. These surprising bounds appear to be accomplished by a sudden jerk, which is given to its body by the animal from a bent into a straight position. If they fail in their attempt, and fall back into the stream, it is only to rest a short time, and thus recruit their strength for a new effort. The fall of Kilmaroc, on the Beauly, in Inverness-shire, is one of the spots where the leaping feats of the salmon can best be witnessed. "The pool below that fall," says Mr. Mudie, in the *British Naturalist*, "is very large, and as it is the head of the run in one of the finest salmon rivers in the north, and only a few miles distant from the sea, it is literally thronged with salmon, which are continually attempting to pass the fall, but without success, as the limit of their perpendicular spring does not appear to exceed twelve or fourteen feet; at least, if they leap higher than that, they are aimless and exhausted, and the force of the current dashes them down again before they have recovered their energy. They often kill themselves by the violence of their exertions to ascend, and sometimes they fall upon the rocks and are captured. It is indeed said that one of the wonders which the Frasers of Lovat, who are lords of the manor, used to show their guests was a voluntarily cooked salmon at the falls of Kilmaroc. For this purpose a kettle was placed upon the flat rock on the south side of the fall, close by the edge of the water and kept full and boiling. There is a considerable extent of the rock where tents were erected, and the whole was under a canopy of overshadowing trees. There the company are said to have waited until a salmon fell into the kettle, and was boiled in their presence. We have seen as many as eighty taken in a pool lower down the river at one haul of the seine, and one of the number weighed more than sixty pounds."

As the salmon laboriously ascend the rivers, it may easily be

imagined that the cunning and rapacity of man seeks every opportunity to intercept their progress. Nets of the most various form and construction are employed for their capture; numbers are entrapped in enclosed spaces formed in weirs, into which they enter as they push up the stream, and are then prevented by a grating of a peculiar contrivance from returning or getting out; and many are speared, a mode frequently practised at night-time, when torches are made use of to attract them to the surface, or to betray them by their silvery reflection to the attentive fisherman.

The ruddy gleam illumining the river banks or sparkling in the agitated waters, the black sky above, the deep contrasts of light and shade, attach a romantic interest to this nocturnal sport, which has been both practised and sung by Walter Scott.

> "'Tis blithe along the midnight tide
> With stalwart arm the boat to guide,
> On high the dazzling blaze to rear
> And heedful plunge the barbed spear.
> Rock, wood, and scour emerging bright,
> Fling on the stream their ruddy light,
> And from the bank our band appears
> Like Genii armed with fiery spears."

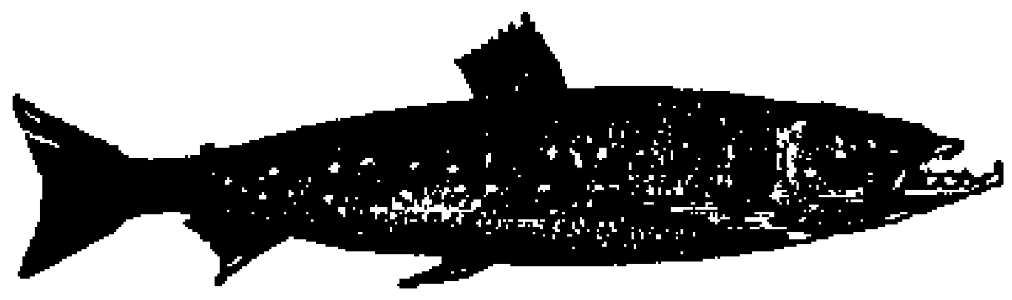
The natural history of the salmon was until lately but very imperfectly known, as the parr (brandling, samlet) and the grilse, which are now fully proved to be but intermediate stages of its growth, were supposed by Yarrell to be distinct fishes. The first person who seems to have suspected the true nature of the parr was James Hogg, the Ettrick shepherd, who in his usual eccentric way took some pains to verify his opinion. As an angler, he had often caught the parr in its transition state, and had frequently captured smolts (at that time the only acknowledged youthful salmon) with the scales barely covering the bars or finger marks of the parr. Wondering at this, he marked a great number of the lesser fish and offered rewards of whisky (being himself a great admirer of the genuine mountain-dew) to the peasantry to bring him any fish that had evidently undergone the change. These crude experiments of the talented shepherd convinced him that the parr were the young of the salmon in the first stage, and since then professed naturalists have fully settled the question by watching the egg into life, and tracing

the growth of the young fish step by step until it ultimately changed into the kingly salmon.

This ignorance of the true nature of the parr had most disastrous effects, as it largely contributed to the depopulation of our streams, for the farmers and cottars who resided near the rivers used not unfrequently, after filling the frying-pan with parr, to feed their pigs with them, and myriads were annually killed by juvenile anglers. This truly deplorable havoc has fortunately been arrested by Act of Parliament, but the killing of grilse is still, I believe, a fertile source of destruction,* and should undoubtedly be restrained by law, as the wholesale slaughter of these juvenile fishes is a most lamentable example of improvident waste.

In former times our rivers abounded with salmon, more than 200,000 having been caught in a single summer in the Tweed alone, and 2,500 at one haul in the river Thurso; but, besides the causes above mentioned, over fishing or fishing at an improper season, and probably in many cases the pollution of the streams with deleterious matter from mines or manufactories, have considerably reduced their numbers. Fortunately, public attention has at length been thoroughly aroused to the danger which menaces our king of fishes; and, what with better laws for his protection and the successful attempts that have latterly been made in artificial fish-breeding, we may hope that more prosperous times are in store for our salmon-fisheries.

The salmon not only frequents the streams of Northern Europe but ascends in vast multitudes the giant rivers of Siberia and of North America. It is fished by the Ostjak and the Tunguse, and speared by the Indian of the New World. Ross's Arctic salmon, which is of a more slender form than the common salmon, differently marked and coloured, and with a remarkably long under jaw, is so extremely abundant in the sea near the mouths of the rivers of Boothia Felix that 3,378 were obtained at one haul of a small-sized seine. The rivers of Kamtschatka abound in salmon of various kinds, so that the stream,


Salmo Rossii

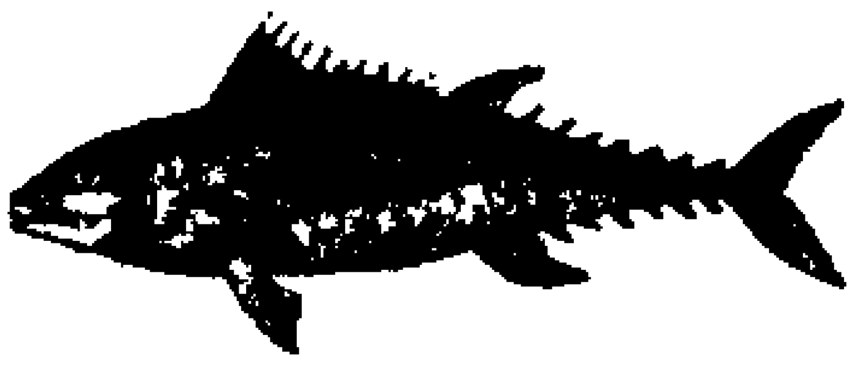
* In 1862, 8,467 salmon and 25,042 grilse were captured in the Tweed.

swelling as it were with living waves, not seldom overflows its banks and casts multitudes ashore. Steller affirms that, in that almost uninhabited peninsula, the bears and dogs and other animals catch more of these fishes with their mouths and feet than man in other countries with all his cunning devices of net and angle.

The salmon of Iceland, which formerly remained undisturbed by the phlegmatic inhabitants, are now caught in large numbers for the British market. A small river, bearing the significant name of Laxaa or Salmon river, has been rented for the trifling sum of 100*l.* a year by an English company which sends every spring its agents to the spot, well provided with the best fishing apparatus. The captured fish are immediately boiled and hermetically packed in tin boxes, so that they can be eaten in London almost as fresh as if they had just been caught. Other valuable salmon-streams in Iceland and Norway pay us a similar tribute; and as commerce, aided by the steamboat and the railway, extends her empire, rivers more and more distant are made to supply the deficiencies of our native streams. More than 150,000 salmon are annually caught in Aljaska—not a quarter of a century ago a real "ultima Thule"—and after having been well pickled and smoked at the various fishing-stations are chiefly sent from Sitcha to Hamburg.

Nature has denied the salmon to the streams of Australia and New Zealand; but as the eggs of this fish can be preserved for a very long time, they have been transported with perfect success to those far-distant colonies.

If neither the salmon, nor the common herring, nor the cod, dwell in the Mediterranean, the fishermen of that sea rejoice in the capture of the Tunny, the chief of the mackerel or scomberoid family. Its usual length is about two feet, but it sometimes grows to eight or ten; and Pennant saw one killed in 1769, when he was at Inverary, that weighed 460 pounds. The flesh is as firm as that of the sturgeon, but of a finer flavour.

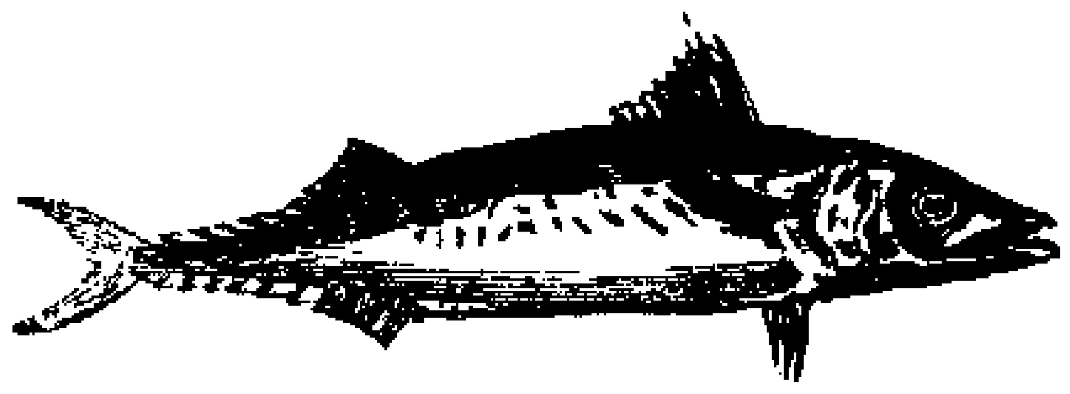


Tunny.

"In May and June," says Mr. Yarrell, "the adult fish rove along the coast of the Mediterranean in large shoals and triangular array. They are extremely timid, and easily induced to take a

new and apparently an open course, in order to avoid any suspected danger. But the fishermen take advantage of this peculiarity for their destruction by placing a look-out or sentinel on some elevated spot, who makes the signal that the shoal of tunnies is approaching, and points out the direction in which it will come. Immediately a great number of boats set off, range themselves in a curved line, and, joining their nets, form an enclosure which alarms the fish, while the fishermen, drawing closer and closer, and adding fresh nets, still continue driving the tunnies towards the shore, where they are ultimately killed with poles.

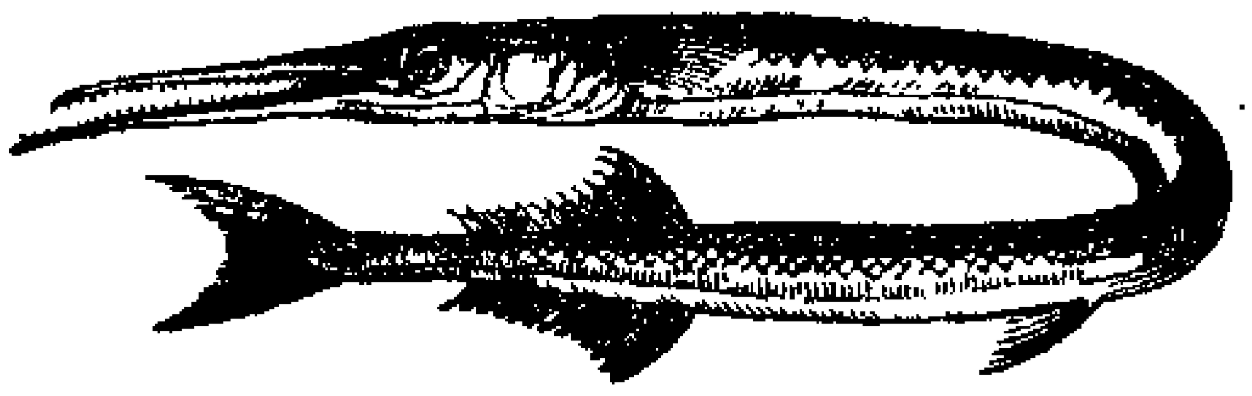
"But the grandest mode of catching the tunny is by means of the French *madrague*, or, as the Italians call it, *tonnaro*. Series of long and deep nets, fixed vertically by corks at their upper edges, and with lead and stones at the bottom, are kept in a particular position by anchors, so as to form an enclosure parallel to the coast, sometimes extending an Italian mile in length; this is divided into several chambers by nets placed across, leaving narrow openings on the land side. The tunnies pass between the coast and the tonnaro; when arrived at the end, they are stopped by one of the cross-nets, which closes the passage against them, and obliges them to enter the tonnaro by the opening which is left for them. When once in, they are driven by various means from chamber to chamber to the last, which is called the chamber of death. Here a strong net, placed horizontally, that can be raised at pleasure, brings the tunnies to the surface, and the work of destruction commences. The tonnaro fishery used to be one of the great amusements of rich Sicilians, and, at the same time, one of the most considerable sources of their wealth. When Louis XIII. visited Marseilles, he was invited to a tunny-fishery, at the principal *madrague* of Morgiou, and found the diversion so much to his taste that he often said it was the pleasantest day he had spent in his whole progress through the south."



Mackerel.

The elegant shape and beautiful colouring of the common Mackerel are too well known to require any particular description, and its qualities as an edible fish have been long duly appreciated. It dies very soon after it is taken out of the water, exhibits for a short time a phosphoric

light, and partly loses the brilliancy of its hues. Like all other members of the family, it is extremely voracious, and makes great havoc among the herring-shoals, although its own length is only from twelve to sixteen inches. It inhabits the northern Atlantic, and is caught in large numbers along the British coast, where it is preceded in its annual visit by the Gar-fish, which for this reason has received also the name of Mackerel-guide. The older naturalists ascribed to the mackerel the same distant migrations as to the tunny, but most probably it only retires during the winter into the deeper waters, at no very great distance from the shores, where it appears during the summer season in such incalculable numbers.



Gar-Fish.

The mackerel is caught with long nets or by hand-lines. It bites greedily at every bait, but generally such a one is preferred as best represents a living prey darting through the water—either some silvery scaled fish, or a piece of metal, or of scarlet cloth. With swelling sails the boat flies along, and a sharp wind is generally considered so favourable that it is called a "Mackerel-breeze." The line is short, but made heavy with lead, and in this manner a couple of men can catch a thousand in one day. The more rapid the boat the greater the success, for the mackerel rushes like lightning after the glittering bait, taking it for a flying prey. The chieftains of the Sandwich Islands used to catch the bonito mackerels in a similar way, by attaching flying-fish to their hooks, and rapidly skimming the surface of the waters. Thus everywhere man knows how to turn to his advantage the peculiar instincts or habits of the animal creation.

Bonito.

The author of "Wild Sports of the West" has favoured us with an animated description of mackerel-fishing on the coast of Ireland.

"It was evident that the bay was full of mackerel. In every direction, and as far as the eye could range, gulls and puffins

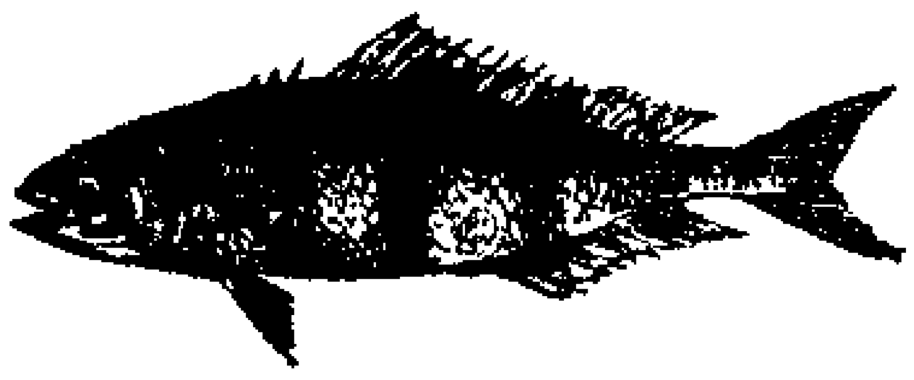
were collected, and, to judge by their activity and clamour, there appeared ample employment for them among the fry beneath. We immediately bore away for the place where these birds were numerously congregated, and the lines were scarcely overboard when we found ourselves in the centre of a shoal of mackerel. For two hours we killed these beautiful fish, as fast as the baits could be renewed and the lines hauled in; and when we left off fishing, actually wearied with sport, we found that we had taken above five hundred, including a number of the coarser species, called Horse-mackerel. There is not, on sea or river, always excepting angling for salmon, any sport comparable to this delightful amusement: full of life and bustle, everything about it is animated and exhilarating; a brisk breeze and fair sky, the boat in quick and constant motion, all is calculated to interest and excite. He who has experienced the glorious sensations of sailing on the Western Ocean, a bright autumnal sky above, a deep-green lucid swell around, a steady breeze, and as much of it as the hooker can stand up to, will estimate the exquisite enjoyment our morning's mackerel-fishing afforded."

Although an occasional visitor of our shores, the Bonito, or Stripe-bellied Tunny (*Thynnus pelamys*), which is much inferior in size to the common tunny of the Mediterranean and the Black Sea, is a true ocean-fish, and generally met with at a vast distance from land. It inhabits the warmer seas, of which it is one of the most active and voracious denizens. It is well known to all voyagers within the tropics for the amusement it affords by its accompanying the vessel in its track, and by its pursuit of the flying-fish. But in its turn the predacious Bonito is subject to the persecutions of the huge Sperm whale, who will often drive whole shoals before him, and crush dozens at a time between his prodigious jaws.

The Pelamid (*Thynnus sarda*), which abounds in all districts of the Mediterranean and on both sides of the Atlantic, has but very lately been discovered in the British waters, a single specimen having been caught a few years ago at the mouth of the North Esk. It greatly resembles the species just mentioned in form and mode of life, prowling about the high seas for cephalopods and flying-fishes, and is very commonly confounded with the bonito by sailors, who also give both of them the name of Skip-jacks, expressive of the habit which many of the large

Scomberoids have of skimming the surface of the sea, and springing occasionally into the air.

Another member of the mackerel family, the Pilot-Fish (*Naucrates ductor*), easily recognised by the three dark-blue bands which surround its silvery body, will frequently attend a ship during its course at sea for weeks or even months together, most likely to profit by the offal thrown overboard. Regardless of the useful precept, "avoid bad company," it is frequently found attending the white shark, and owes its name to its being supposed to act as a trusty guide or friendly monitor to that voracious monster, sometimes directing it where to find a good meal, and at others warning it when to avoid a dangerous bait. At all events, the pilot-fish is well rewarded for his attendance by snatching up the morsels which are overlooked by his companion, and as he is an excellent swimmer, and probably keeps a good look-out, has but little reason to fear being snatched up himself.



Pilot-Fish.—(Naucrates ductor.)

"It has been observed," says Yarrell, "that when a shark and his pilot were following a vessel, if meat was thrown overboard cut into small pieces, and therefore unworthy the shark's attention, the pilot-fish showed his true motive of action by deserting both shark and ship to feed at his leisure on the morsels."

The family of the anguilliform fishes, characterised by their serpent-like bodies, destitute of ventral fins, and generally covered by a slippery skin, with, in some of the genera, small scales embedded therein, likewise comprises a number of highly interesting and useful species, forming many generic groups.

Its chief representative in our waters is the Common Eel (*Anguilla vulgaris*), which, though a frequent inhabitant of our lakes, ponds, and rivers, may also justly be reckoned among the marine fishes; for the same wonderful instinct which prompts the salmon and the sturgeon annually to leave the high seas and seek the inland streams for the sake of perpetuating their race, forces also the eel to migrate, but his peregrinations are of an opposite character, for here the full-grown fishes descend the rivers to deposit their spawn in the sea, and the young, after having been born in the brackish estuaries, ascend the

streams to accomplish their growth in the sweet waters. The mode of procreation of eels, which for ages had been an enigma, has now at length been completely elucidated by Professor Rathke, who discovered that the eggs, which are of microscopic smallness, so as to be undistinguishable by the naked eye from the fat in which they lie imbedded, are expelled through an opening hardly large enough to admit the point of a needle. The energy of the salmon in swimming stream-upwards for hundreds and hundreds of miles, and bounding over rapids and cataracts, is truly wonderful, but the instinctive efforts of the little eels or *elvers* to surmount obstacles that seem quite out of proportion to their strength are no less admirable. Mr. Anderson, upwards of a century ago, described the young eels as ascending the upright posts and gates of the waterworks at Norwich until they came into the dam above; and Sir Humphry Davy, who was witness of a vast migration of elvers at Ballyshannon, speaks of the mouth of the river under the fall as blackened by millions of little eels. "Thousands," he adds, "died, but their bodies remaining moist, served as the ladder for others to make their way; and I saw some ascending even perpendicular stones, making their road through wet moss, or adhering to some eels that had died in the attempt. Such is the energy of these little animals that they continue to find their way in immense numbers to Loch Erne. Even the mighty fall of Schaffhausen (which stops the salmon) does not prevent them from making their way to the Lake of Constance, where I have seen many very large eels." After the little eels have gained the summit of a fall, they rest for a while with their heads protruded into the stream. They then urge themselves forward, taking advantage of every projecting stone or slack water, and never get carried back by the current. Myriads are destroyed on the way by birds or fishes; but, as usual, their greatest enemy is man, who not only devours whole cart-loads of little eels not larger than a knitting-needle, frying them into cakes, which are said to be delicious, though rather queer-looking from the number of little eyes with which they are bespangled, but after getting tired of eating them, actually feeds his pigs with them, or even uses them for manure. A prodigal waste which should be looked after, as these little eels would soon increase their weight, and consequently their

value a thousand fold. On the Continent many lakes and ponds have been stocked with elvers, packed in wet grass, and sent by the railroads or the post far into the interior of the country.

Eels are pre-eminently nocturnal animals. They always congregate at the darkest parts of the stews in which they are kept, and invariably select the darkest nights for their autumnal migration to the sea. Owing to the smallness of their gill aperture, the membranous folds of which, by closing the orifice when the eel is out of the water, prevents the desiccation of the branchiæ, they have the power of living a long time out of the water when the air is humid, and not unfrequently travel during the night over the moist surface of meadows or gardens in quest of frogs or other suitable food.

That eels are not devoid of sagacity is proved by many well authenticated anecdotes. "In Otaheite," says Ellis in his "Polynesian Researches," "they are fed till they attain an enormous size. These pets are kept in large holes two or three feet deep, partially filled with water. On the sides of these pits they generally remain, excepting when called by the person who feeds them. I have been several times with the young chief when he has sat down by the side of the hole, and by giving a shrill sort of whistle has brought out an enormous eel, which has moved about the surface of the water and eaten with confidence out of his master's hand."

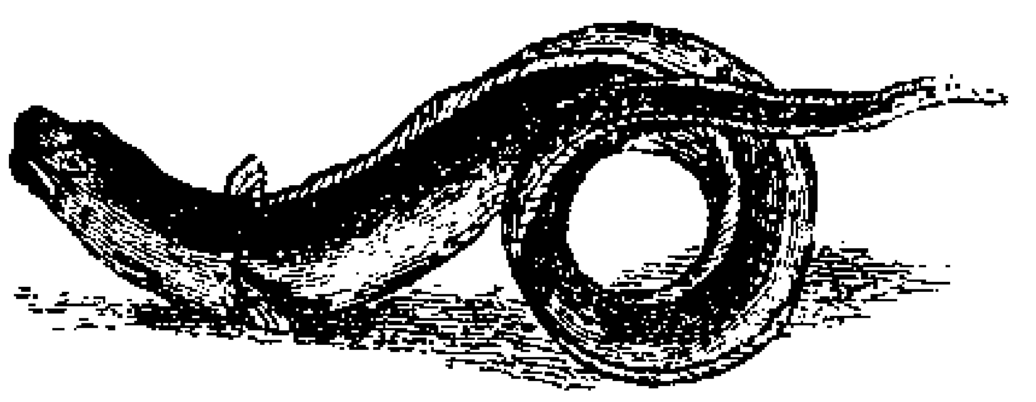
The eel has many enemies, among others the common heron, who, in spite of the slippery skin of his victim, knows how to drive his denticulated middle claw into his body, or to strike him with his pointed bill. Yarrell relates that a heron had once struck his sharp beak through the head of an eel, piercing both eyes, and that the eel—no doubt remembering that one good turn deserves another—had coiled itself so tightly round the neck of the heron as to stop the bird's respiration: both were dead.

The London market is principally supplied with eels from Holland, a country where they abound. According to Mr. Mayhew, about ten millions of eels, amounting to a weight of 1,500,000 lbs., are annually sold in Billingsgate market. These figures show us at once that the multiplication of eels in our sluggish rivers, which only contain such fish as are comparatively speaking worthless, is a matter worth consideration, and

powerfully pleads for the protection and transplantation of the elvers wherever they are likely to prosper.

Eels are extremely susceptible of cold; none whatever are found in the Arctic regions, and at the approach of winter they bury themselves in the mud, where they remain in a state of torpidity until the genial warmth of spring recalls them to a more active state of existence. In this condition they are frequently taken by eel-spears, and in Somersetshire the people know how to find the holes in the banks of rivers in which eels are laid up, by the hoar-frost not lying over them as it does elsewhere, and dig them out in heaps. Though generally only from two to three feet long, eels sometimes acquire a much larger size. Specimens six feet long and fifteen pounds in weight are occasionally captured, and Yarrell saw at Cambridge the preserved skins of two which weighed together fifty pounds. They were taken on draining a fen-dyke at Wisbeach. As eels are but slow in growth, these sizes speak for a great longevity.

The Conger is in its general appearance so nearly allied to the common eel that it might easily be mistaken for the same species. It, however, materially differs from it by its darker colour in the upper part, and its brighter hue beneath, by its dorsal fin beginning near the head, and by its snout generally projecting beyond the lower jaw.



Conger Eel.

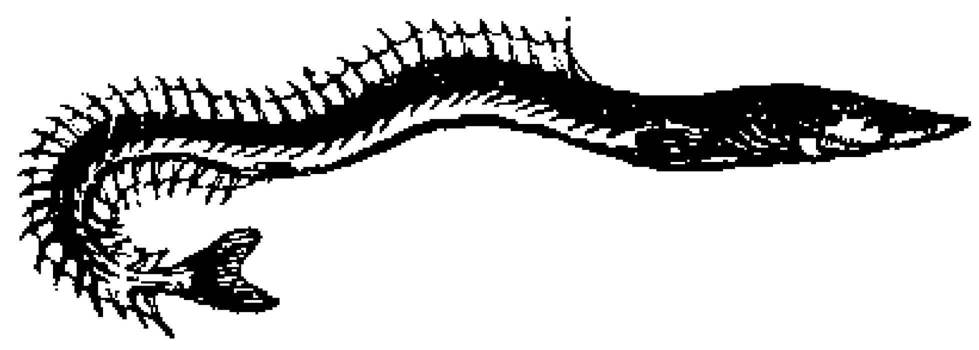
This marine giant of the eel tribe attains a length of ten feet, and a weight of 130 pounds, and is well known on all the rocky parts of the coast of the British Islands, though nowhere more abundant than on the Cornish coast, where, according to Mr. Couch, it is not uncommon for a boat with three men to bring on shore from five hundredweight to two tons. The fishing for congers is always performed at night, and not unattended with danger, as it is quite a common occurrence for a conger to attack the fishermen with open jaws, and so great is the strength of the large specimens that they have occasionally succeeded in pulling the fisherman quite out of his boat, if by any chance he has fastened the line to his arm. The congers that keep among rocks hide themselves in crevices, where they are not unfrequently left by the retiring tide; but in situations free

from rocks, congers hide themselves by burrowing in the ground, where it is customary on some parts of the coast of France to employ dogs in their search. In spite of its tough flesh and exceedingly nauseous smell, the conger was highly esteemed by Greek epicures, and in England in the time of the Henrys considered an article of food fit for a king. Thus, the Prince and Poins, according to Falstaff's account, found amongst other reasons for their companionship this one: that both of them were fond of conger and fennel sauce. In our times its flesh, though banished from all aristocratic tables, meets a ready sale at a low price among the poorer classes. In the Isle of Man the conger may be said to take the place of the poor man's pig; it is his bacon, which he would find difficult to save if it were not for these large eels, which are caught in great abundance, and sold at the rate of 2*d.* or 3*d.* per lb. The Manx men split the congers, and then salt them and hang them up to dry on their cottage walls, where they do not exactly contribute to perfume the gale.

The Murry or Muræna differs from the common eel by the want of pectoral fins, and its beautifully-marked skin. It is said to live with equal facility in fresh or salt water, though generally found at sea, and it is as common in the Pacific as it is in the Atlantic and Mediterranean. The only specimen on record as a British fish was caught by a fisherman of Polperro, October 8, 1834; its length was four feet four inches. The muræna has acquired a kind of historical celebrity from the strange fondness with which it was cherished by the Romans, who preserved large quantities of them in their numerous vivaria, as we do the lustrous gold-fish in the water-basins of our gardens. A certain Cajus Hirrius, who lived in the time of Julius Cæsar, was the first that introduced the fashion, which soon became a passion among the wealthy senators and knights of the imperial city, who used to deck their especial pets with all kinds of ornaments. The celebrated orator, Hortensius, the rival of Cicero, had a *piscina* at Bauli, on the gulf of Baiæ, where he took great delight in a favourite murry that would come at his call and feed from his hand. When the creature died, he was unable to stop his tears; and another celebrated Roman, L. Licinius Crassus, appears to have had an equally tender heart, for he, too, wept at the death of his fishy darling.

Vedius Pollio, a Roman knight, has even acquired through these fishes a scandalous renown, by causing now and then a slave that had been guilty of some slight offence to be cast alive and naked into their piscina, and amusing himself with the sight of the murrys lacerating and devouring the body. That this wretch was a friend of the Emperor Augustus harmonises but badly with the ideas of the urbanity of his court which we may have formed from the poems of Horace and Virgil. It is but fair, however, to the character of the emperor to state that he reprobated Pollio's cruelty, and ordered his fish-pond to be filled up.

The Launces are distinguished from the eels by their large gill openings, and their caudal fin being separated from their dorsal and anal fins. The common Sand Launce abounds on many parts of our shore. On account of its silvery brightness it is highly esteemed by the fishermen as bait for their hooks, and its remarkable habit of burrowing in the sand as the tide recedes affords easy means of capture. While underground, it most likely gets hold of many an unfortunate lob-worm, mollusc, or crustacean, but on emerging from its retreat it is in its turn preyed upon by the larger fishes. On a calm evening it is an interesting sight to see the surface of the water broken by the repeated plunges of the voracious mackerel as they burst upon the launces from beneath. On the sands at Portobello, near Edinburgh, people of all ages may be seen when the tide is out diligently searching for the sand launce, and raking them out with iron hooks. On the south coast of Devonshire, where the sand launces are extremely plentiful, the fishermen employ a small seine with a fine mesh, and are frequently so successful that six or seven bushels are taken at one haul. The usual length of the sand launce is from five to seven inches. In many localities it is prepared for table, and considered a great delicacy.

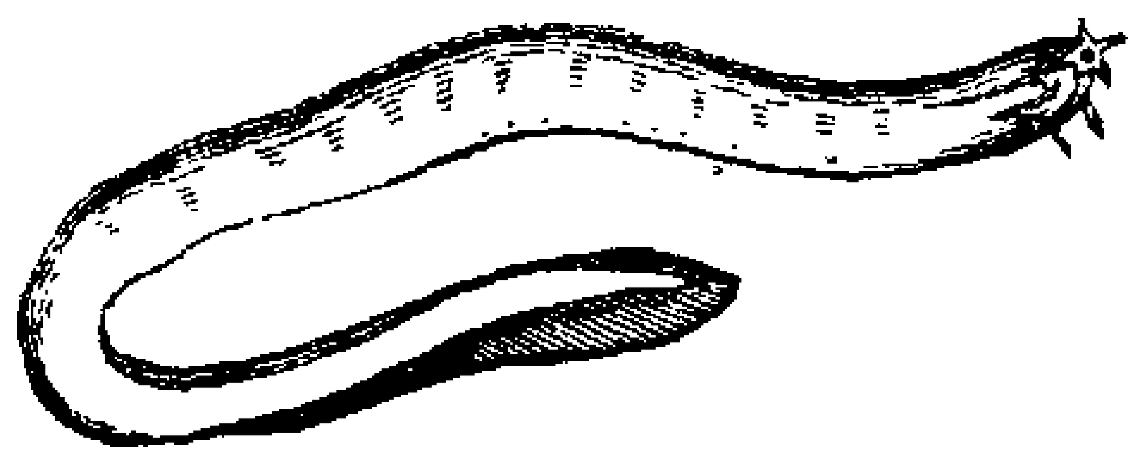


Ammodyte, or Launce.

Although the Lamprey essentially differs from the eel in the formation of its gills, the softness of its cartilaginous skeleton, and its funnel-shaped mouth provided with sharp teeth, disposed in circles, yet it resembles it closely in its outward form. Its

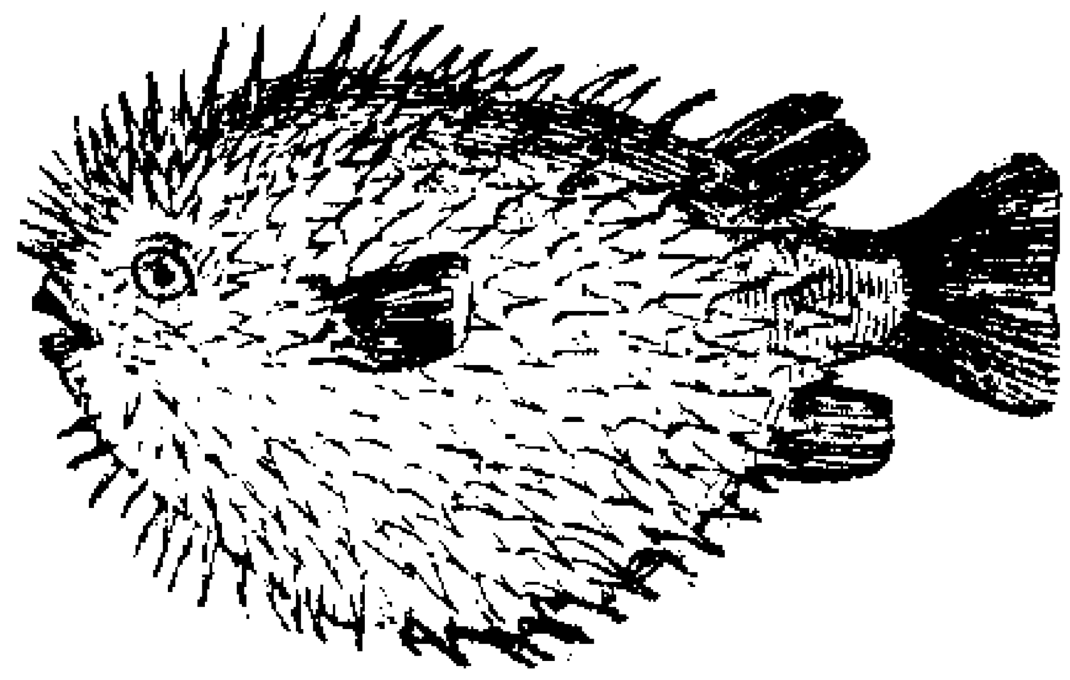
colour is generally a dull brownish olive, clouded with yellowish-white variegations; the fins are tinged with dull orange, and the tail with blue. The Marine or Sea Lamprey inhabits the ocean, but ascends the rivers in spring. Though capable of swimming with considerable vigour and rapidity, it is more commonly seen attached by the mouth to some large stone or other substance, the body hanging at rest, or obeying the motion of the current. Its power of adhesion is so great that a weight of more than twelve pounds may be raised without forcing the fish to quit its hold. Like the eel, it is remarkably tenacious of life, the head strongly attaching itself for several hours to a stone, though by far the greater part of the body be cut away from it. The lamprey is still considered as a delicacy; every schoolboy knows that King Henry I. died of an indigestion caused by this favourite dish ; and the town of Gloucester still sends every Christmas a lamprey-pie to Queen Victoria, such as it was wont to offer to its sovereign in the days of the Plantagenets and Tudors.

The Myxine, Glutinous Hag, or Borer, bears a near resemblance to the lamprey, but stands upon a much inferior degree of organisation, having no eyes—(the sole example of blindness among fishes), and a still softer skeleton, so that, when boiled, it almost entirely dissolves into mucus. In the lamprey and myxine, the branchial cells, which admit water, are lined by the delicate membrane through which the blood is aërated. In the former, however, the external apertures of the branchial cells are placed on the side of the neck; while in the myxine, which feeds on the internal parts of its prey, and buries its head and part of its body in the flesh, the openings of the respiratory organs are removed sufficiently far back to admit of the respiration going on while the animal's head is so inserted. Thus, even in this lowest and meanest of all vertebrate animals, we find a remarkable adaptation of its construction to its wants, and the proof that it has been as well taken care of by its Creator as the highest organised creatures of its class.

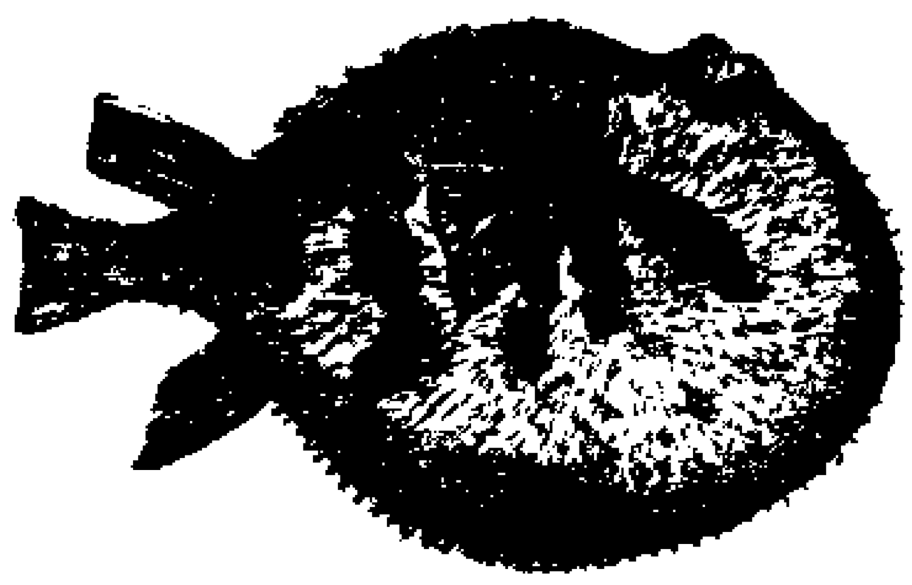

Myxine.

One of the most remarkable orders of fishes is that of the

Plectognaths, which are distinguished by having the superior maxillary bones and the intermaxillaries soldered together so as to render the upper jaw immovable, or incapable of projection. Among the Plectognaths, we find among others the prickly Globe-

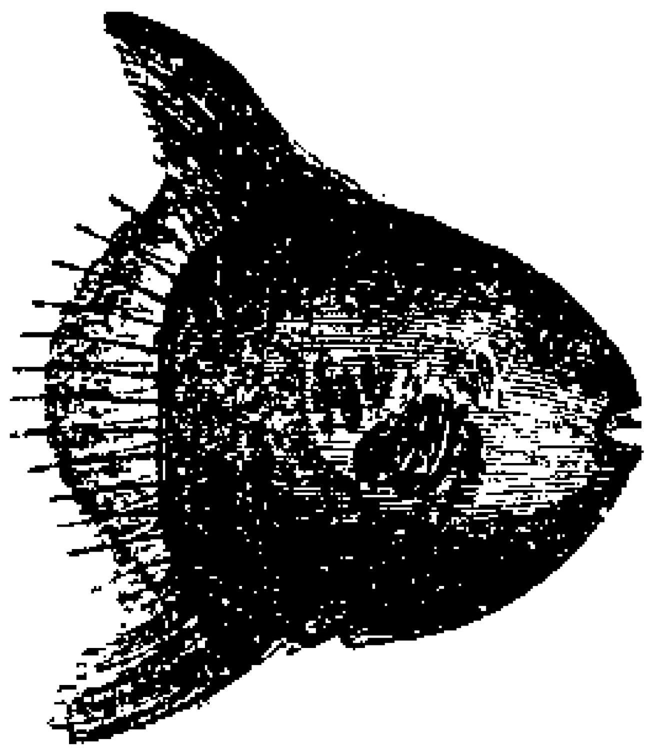


Porcupine-Fish.—(Diodon hystrix.)

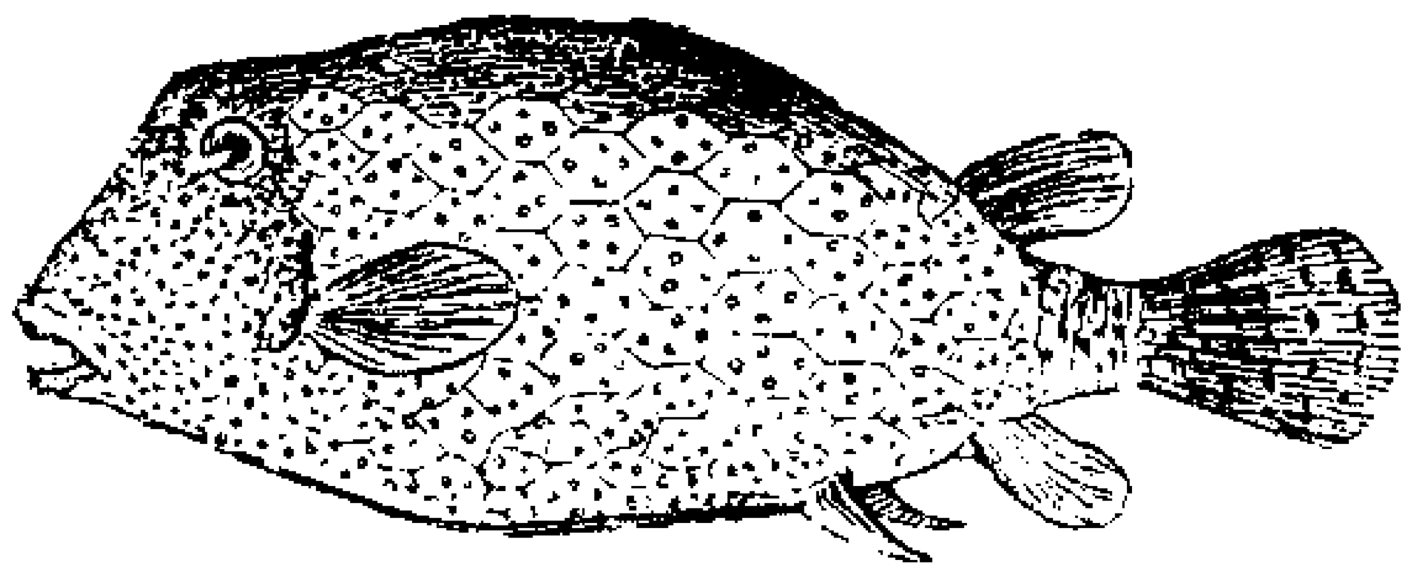


Globe-Fish.

fishes and sea-porcupines; the curiously-shaped Sun-fishes, all head and no body; the Ostracions or Trunk-fishes, clothed like the armadillos in a defensive coat of mail, leaving only the tail,

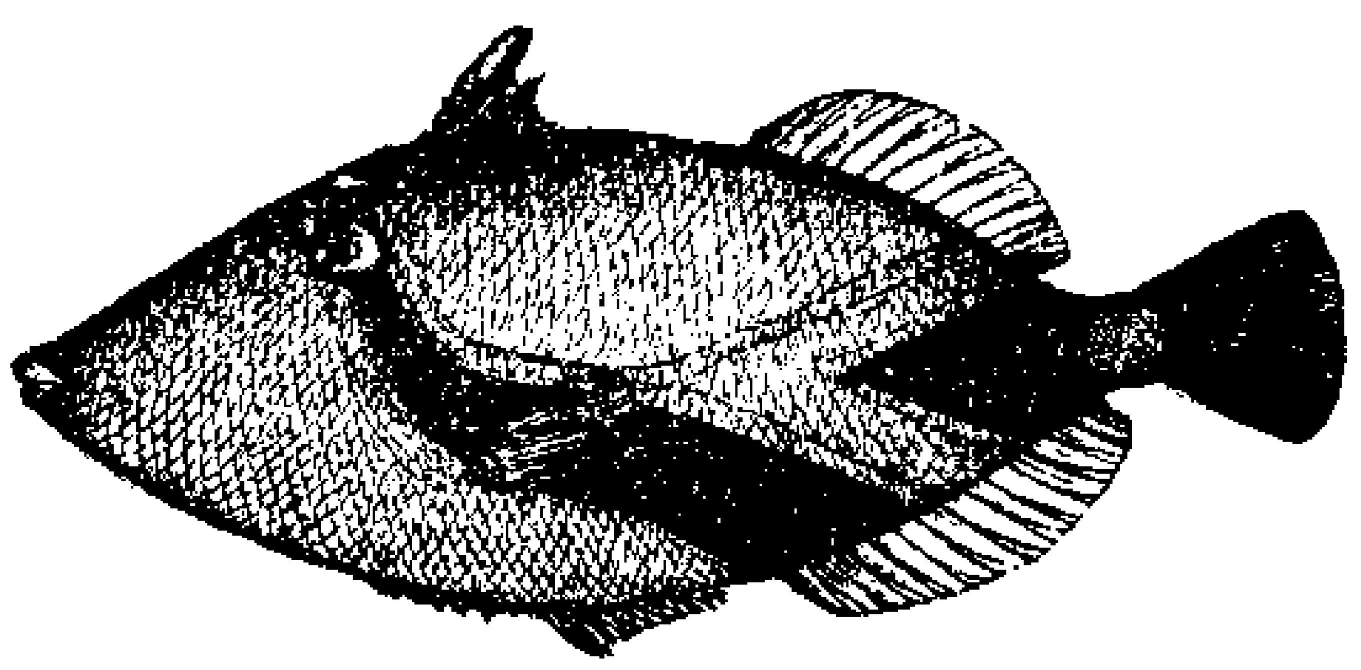


Short Sun-Fish.
(Orthagoriscus Mola.)



Trunk-Fish.—(Ostracion triqueter.)

fins, mouth, and a small portion of the gill-opening, capable of motion; and the gorgeous Balistæ or File-fishes, which owe their family-name to the peculiar structure of their first dorsal fin. The first and strongest spine of this organ is studded up the front with numerous small projections, which, under the microscope, look like so many points of enamel or



File-Fish.—(Balistes erythropterus.)

pearl arising from the surface of the bone and giving it the appearance of a file. The second smaller spine has in the fore part of its base a projection which, when the spines are elevated, locks into a corresponding notch in the posterior base of the first spine, and fixes it like the trigger of a gun-lock; from which the fish is called in Italy *pesce balestra*, or the cross-bow

fish. The strong spine cannot be forced down till the small one has been first depressed and the catch disengaged.

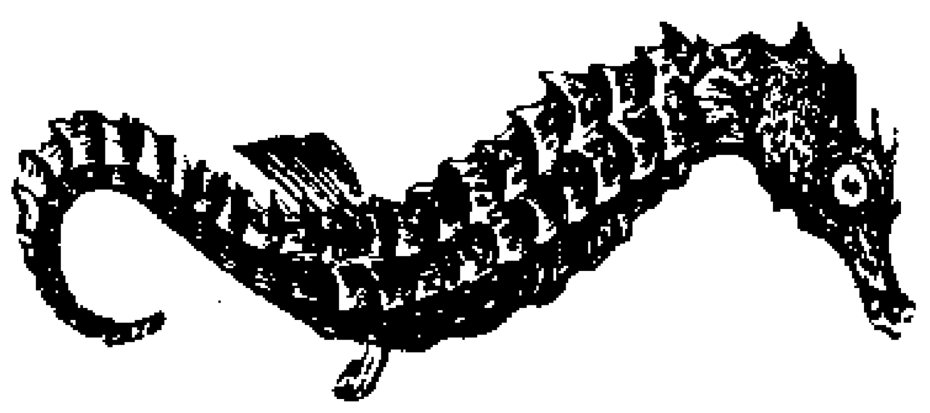
The Plectognaths are mostly denizens of the warmer seas, but the pig-faced trigger-fish of the Mediterranean (*Balistes capriscus*) has been caught three times in the British waters since 1827. and the short sun-fish or molebut, though occurring but occasionally, may be said to have been taken from John o' Groat's to the Land's End. It grows to an immense size, often attaining the diameter of four feet, sometimes even double that size, and occasionally weighing from 300 to 500 pounds. When observed in our seas, the sun-fishes have generally appeared as though they were dead or dying, floating lazily along on one side and making little or no attempt to escape. It is to be presumed that in more congenial waters they evince a greater degree of liveliness.

The order of the Lophobranchii is in many respects too curious and interesting to be passed over in silence. Here the gills, instead of being as usual ranged like the teeth of a comb, are clustered into small filamentous tufts placed by pairs along the branchial arches; the face projects into a long tubular snout, having the mouth either at its extremity, as in the Hippocampus and in the Pipe-fishes, or at its base, as in the Pegasus of the Indian seas; and the body is covered with shields or small plates, which often give it an angular form, and encase it as it were in jointed armour. But the most interesting feature of their economy is the pouches in which the males of the most characteristic genera carry the eggs until they are hatched. In the hippocampi this provision for the safety of the future generation, which strongly reminds one of the kangaroo or the opossum, forms a perfect sack, opening at its commencement only; in the pipe-fishes it is closed along its whole length by two soft flaps folding over each other. Another peculiarity of these interesting little fishes is the independent motion of their eyes, the one glancing hither and thither while its fellow remains motionless, or looks in different directions. This phenomenon of *double* vision, which was long supposed to be peculiar to the chameleon, is, however, not confined to this singular reptile or to the hippocampi and pipe-fishes, but has been found by Mr. Gosse to exist likewise in the Little Weever (*Trachinus vipera*), in the Suckers (Lepidogastri), a small family remarkable

for the power they possess of attaching themselves to stones or rocks by means of an adhesive disk on the under surface of their bodies, and in several other fishes.

When imprisoned in an aquarium, few subjects of the deep display more intelligence or afford more entertainment than the little *Hippocampus brevirostris*, or Sea-Horse.

"While swimming about," says Mr. Lukis,* "it maintains a vertical position, but the tail, ready to grasp whatever meets it in the water, quickly entwines itself in any direction round the weeds, and, when fixed, the animal intently watches the surrounding objects, and darts at its prey with great dexterity. When two of them approach each other, they often twist their tails together, and struggle to separate or attach themselves to the weeds; this is done by the under part of their cheeks or chin, which is also used for raising the body when a new spot is wanted for the tail to fasten upon afresh."



Sea-Horse.

"In captivity," says Mr. Gosse, "the manners of the Worm Pipe-Fish (*Syngnathus lambriciformis*), the smallest of our native species, are amusing and engaging. Its beautiful eyes move independently of each other, like those of the chameleon, and another point of resemblance to that animal our little pipe-fish presents in the prehensile character of its tail. It curves just the tip of this organ laterally round the stem or frond of some sea-weed and holds on by this half-inch or so, while the rest of its body roves to and fro, elevating and depressing the head and fore parts, and throwing the body into the most graceful curves. All the motions of the Pipe-fish manifest much intelligence. It is a timid little thing, retiring from the side of the glass at which it had been lying when one approaches, and hiding under the shadow of the sea-weeds, which I have put in, both to afford it shelter, and also to supply food in the numerous animalcules that inhabit these marine plants. Then it cautiously glides among their bushy fronds, and from under their shelter peeps with its brilliant eyes at the intruder as if wondering what he can be, drawing back gently at any alarming motion. In swimming, it is constantly throwing its body

* Yarrell, "British Fishes," 3rd edition, vol. ii. p. 396.

into elegant contortions and undulations; often it hangs nearly perpendicular with the tail near the surface; now and then it butts against the side of the vessel with reiterated blows of its nose, as if it could not make out why it should not go forward where it can see no impediment. Now it twists about as if it would tie its body into a love knot, then hangs motionless in some one of the 'lines of beauty' in which it has accidentally paused."

The family of the Pleuronectidæ or Flat-fishes recommends itself to our notice as much by the singularity of its form as by its usefulness to man. "The want of symmetry," says Yarrell, "so unusual in vertebrated animals, is the most striking and distinctive character of these fishes: the twisted head with both eyes on the same side, one higher than the other, not in the same vertical line, and often unequal in size; the mouth cleft awry, and the frequent want of uniformity in those fins that are in pairs, the pectoral and ventral fins of the under side being generally smaller; and the whole of the colour of the fish confined to one side, while the other side remains white, produce a grotesque appearance: yet a little consideration will prove that these various and seemingly obvious anomalies are perfectly in harmony with that station in nature which an animal possessing such conformation is appointed to fill.

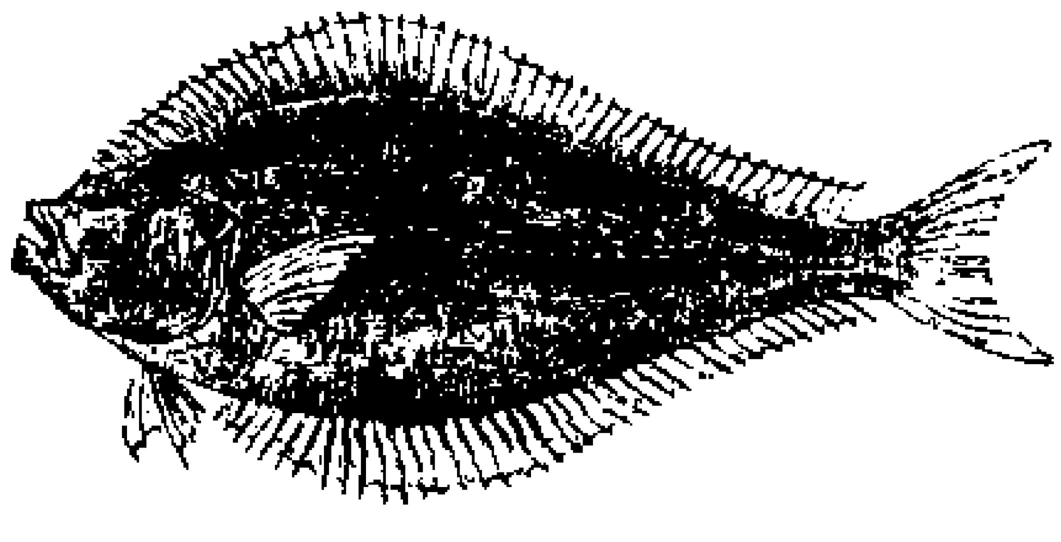
"As birds are seen to occupy very different situations, some obtaining their food on the ground, others on trees, and not a few at various degrees of elevation in the air, so are fishes destined to reside in different depths of water. The flat-fishes and the various species of skate are, by their depressed form of body, admirably adapted to inhabit the lowest position, where they occupy the least space among their kindred fishes."

"Preferring sandy or muddy shores, the place of the flat-fish is close to the ground; where, hiding their bodies horizontally in the loose soil at the bottom, with the head only slightly elevated, an eye on the under side of the head would be useless; but as both eyes are placed on the upper surface, an extensive range of view is afforded in those various directions in which they may either endeavour to find suitable food or avoid dangerous enemies. Light, one great cause of colour, strikes on the upper surface only; the under surface, like that of most other fishes, remains perfectly colourless. Having

little or no means of defence, had their colour been placed only above the lateral line on each side, in whatever position they moved their piebald appearance would have rendered them conspicuous objects to all their enemies. When near the ground, they swim slowly, maintaining their horizontal position; and the smaller pectoral and ventral fins, on the under side, are advantageous where there is so much less room for their action than with the larger fins that are above. When suddenly disturbed, they sometimes make a rapid shoot, changing their position from horizontal to vertical; and, if the observer happens to be opposite the white side, they may be seen to pass with the rapidity and flash of a meteor. Soon, however, they sink down again, resuming their previous motionless horizontal position, and are then distinguished with difficulty, owing to their great similarity in colour to the surface on which they rest."

The number of species of the flat-fishes diminishes as the degrees of northern latitude increase. In this country we have twenty-three species; at the parallel of Jutland there are thirteen; on the coast of Norway they are reduced to ten; in Iceland the number is but five, and in Greenland only three.

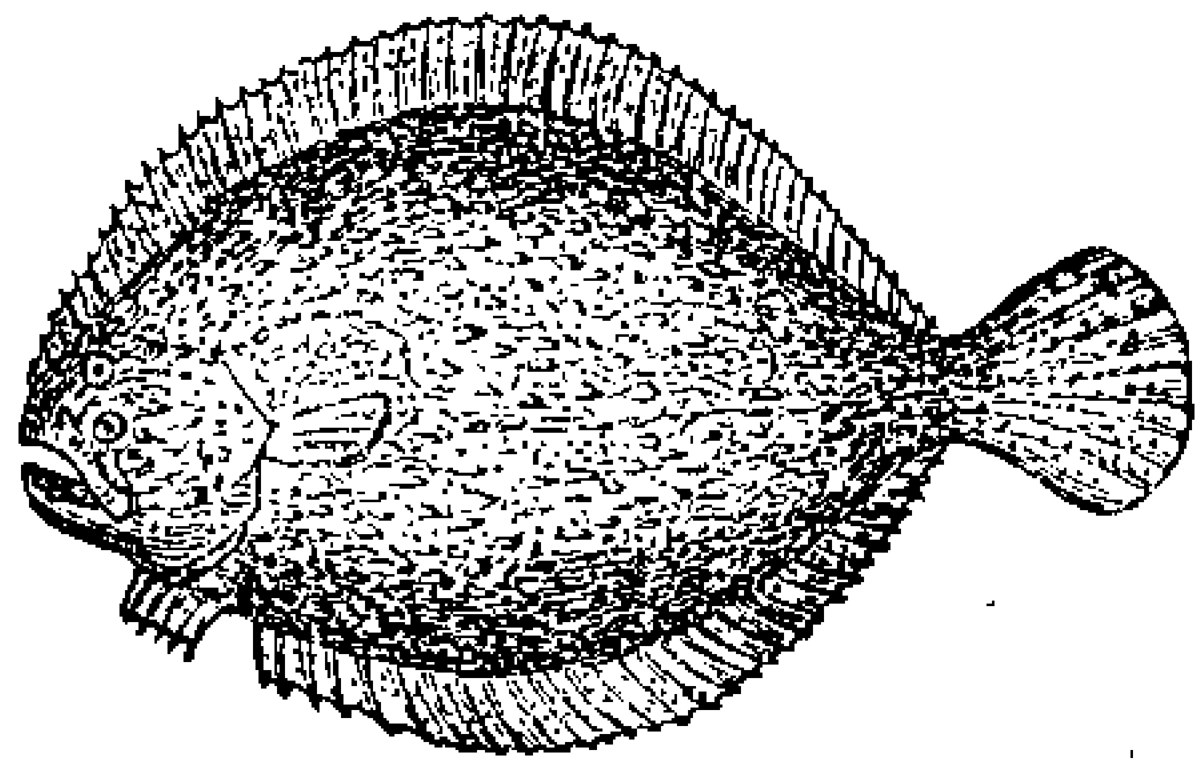
Many of them attain a considerable size, particularly the Halibut (*Pleuronectes hippoglossus*). In April 1828 a specimen seven feet six inches long and three feet six inches broad was taken off the Isle of Man, and sent to Edinburgh market. Olafsen mentions that he saw one which measured five ells; and we are told by the Norwegian fishermen that a single halibut will sometimes cover a whole skiff. Let us, however, remember that these stories proceed from the country where monstrous krakens and sea-snakes are most frequently seen, and where the mists of the north seem to produce strange delusions of vision.


Halibut.

At all events, the halibut is better entitled to the name of *maximus* than its relation the Turbot, to which that epithet has been improperly applied by naturalists. The turbot, equally esteemed by the ancients and the moderns for the delicacy of its flesh, is often confounded in our markets with the halibut, but

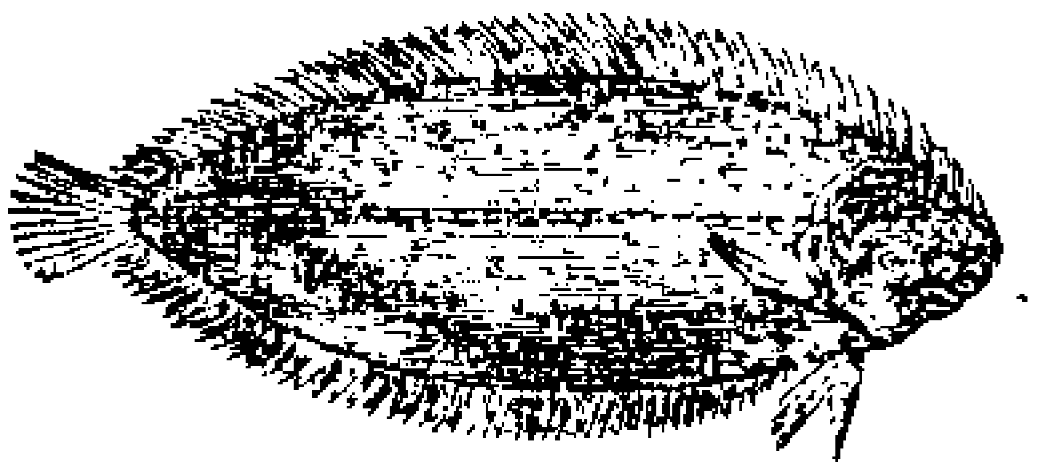
may be easily recognised by the large unequal and obtuse tubercles on its upper part.

The number of turbot brought to Billingsgate within twelve months, up to a recent period, was 87,958. Though very considerable quantities of this fish are now taken on various parts of our own coasts, from the Orkneys to the Land's End, yet a preference is given to those caught by the Dutch fishermen, who are supposed to draw not less than 80,000*l.* for the supply of the London market alone. According to Mr. Low, it is rare along our most northern shores, but increases in numbers on proceeding to the south.



Turbot.

Next to the turbot, the Sole is reckoned the most delicate of the flat-fishes. It inhabits the sandy shore all round our coast, where it keeps close to the bottom, indiscriminately feeding on smaller testaceous animals, crustacea, annelides, radiata, and the spawn and fry of other fishes. It is found northward as far as the Baltic and the seas of Scandinavia, and southward along the shores of Spain, Portugal, and the Mediterranean. The consumption is enormous, for Mr. Bertram informs us that no less than 100,000,000 soles are annually brought to the London market.* They seldom take any bait, and are caught almost



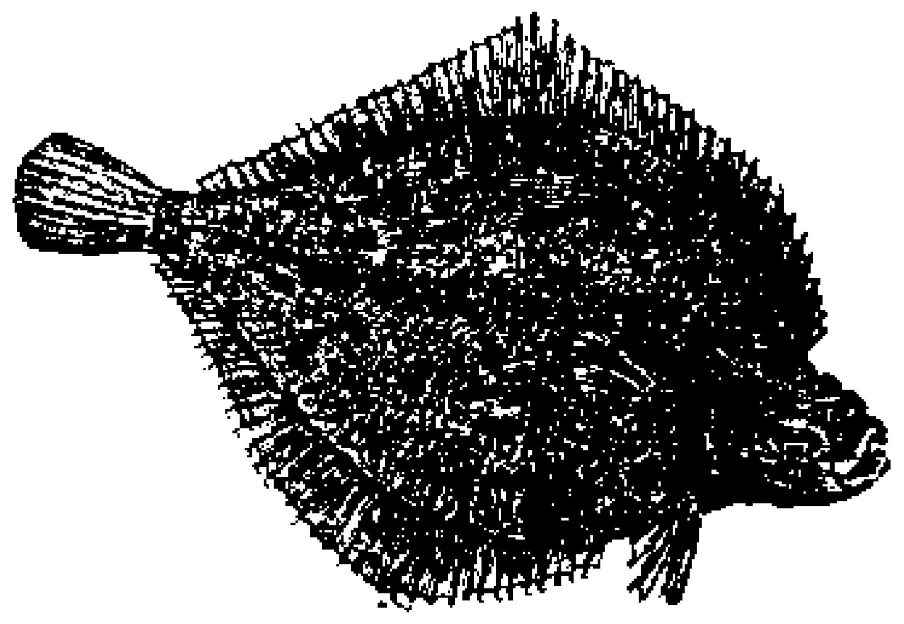
Sole.

* We are told by the same author ("Harvest of the Seas," Murray, 1866) that 500,000 cod-fish, 25,000,000 mackerel, 35,000,000 plaice, and 200,000,000 haddocks, &c., form the yearly supply of the metropolis, which, besides this immense number of white-fish, consumes 50,000,000 red herrings and 1,600,000 dried cod. These, with the addition of Molluscous shell-fish (oysters, &c.) to the amount of 920,000,000, and a daily demand for 10,000 lobsters during the season, afford an instructive indication of what must be the requirement of the whole population of the United Kingdom as regards fish food.

The Report of the Commissioners appointed in the year 1863 to enquire into the sea-fisheries of the United Kingdom gives us the gratifying intelligence that the number of fishermen in Great Britain has nearly doubled within the last twenty years, while the boats are increasing in number and size. No class of the population is said to be in a more flourishing condition; and this prosperity is no doubt mainly due to the railroads, which have opened throughout the whole kingdom

entirely by trawling. The principal fishing-ground in England is along the south coast from Sussex to Devonshire, where the soles are much larger and considered otherwise superior to those of the north and east. On the Devonshire coast, the great fishing-station is at Brixham in Torbay, where the boats, using large trawling nets from thirty to thirty-six feet in beam, produce a continual supply.

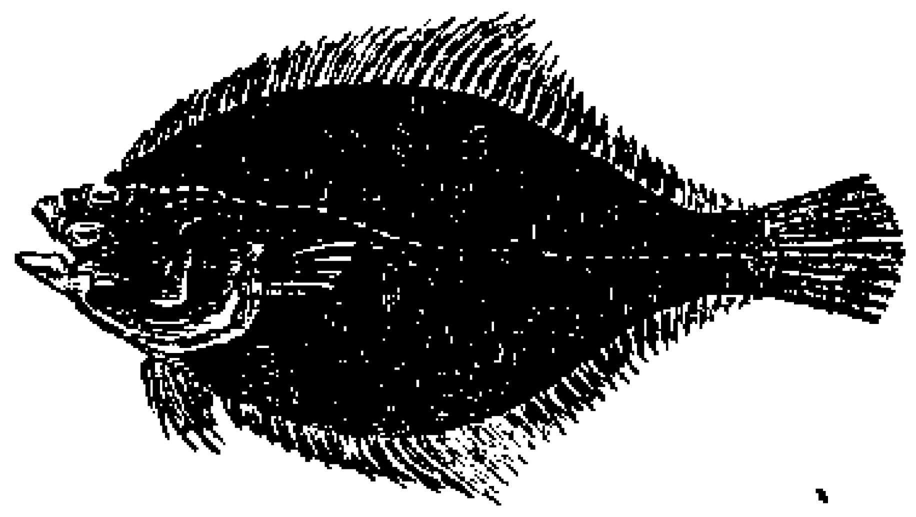
The Plaice and Flounder, though far inferior to the sole in quality, are still in great request as articles of food. On the English coast, the plaice are obtained in abundance on all sandy banks and muddy grounds, wherever either lines or trawl-nets can be used. On the sandy flats of the Solway Frith, they are taken by the fishermen and their families wading in the shoal water with bare feet. When a fish is felt, it is pressed by the foot firmly against the bottom until it can be secured by the hand and transferred to the basket. Long practice gives the dexterity which renders this kind of fishing successful.



Plaice.

In some parts of the North of Europe, where from the rocky nature of the soil the sea is remarkably transparent, plaice and some other flat-fish of large size are taken by dropping down upon them from a boat a doubly-barbed short spear, heavily leaded, to carry it with velocity to the bottom, with a line attached to it, by which the fish, when transfixed, is hauled up.

The Flounder, one of the most common of the flat-fish, is found in the sea and near the mouths of large streams all round our coast, particularly where the bottom is soft, whether of sand, clay, or mud. It also ascends the rivers, and is caught in considerable quantities from Deptford to Richmond by Thames fishermen, who, with the assistance of an apprentice, use a net of a particular sort, called a tuck-sean. "One end of this net," says Yarrell, "is fixed for a short



The Flounder.

a ready market for the produce of the seas. In Ireland, however, there has been a diminution of 10,583 boats and 52,127 men within the same time; a consequence of the famine of 1848, and subsequent emigration.

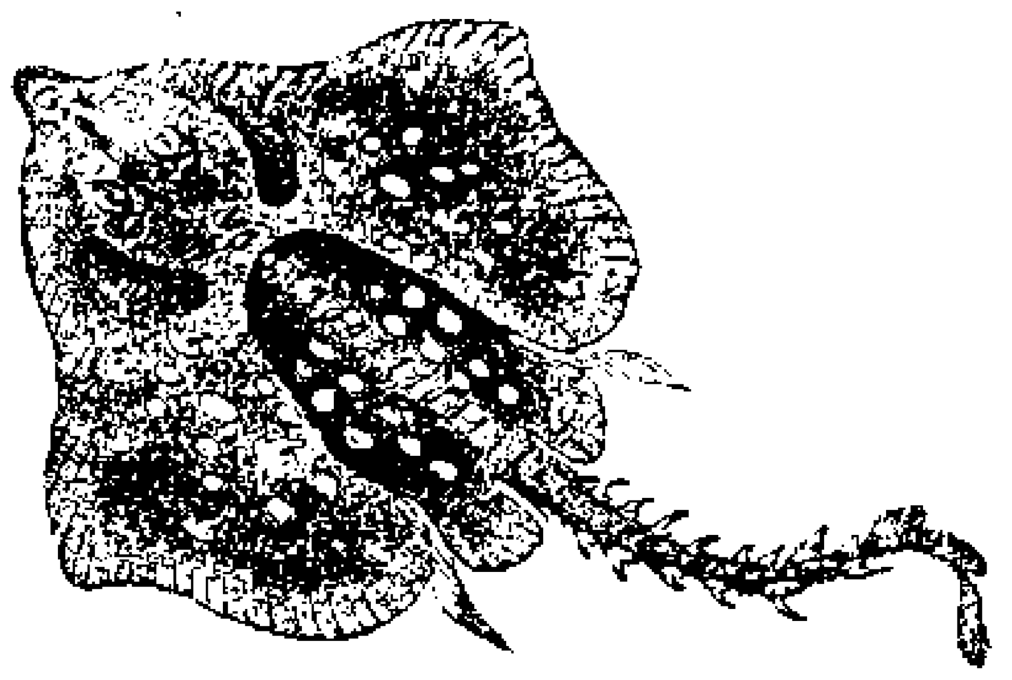
time by an anchor or grapple, and its situation marked by a floating buoy; the boat is then rowed or rather sculled by the apprentice in a circle, the fisherman near the stern handing out and clearing the net: when the circle is completed and a space enclosed, the net is hauled in near the starting-point in a direction across the fixed end."

The Sail-fluke, a species of flat-fish common among the Orkneys, where it is highly prized as an article of food, its flesh being firm and white, is remarkable for its curious habit of coming ashore spontaneously, with its tail erected above the water, like a boat under sail, whence it has derived its name. This it does generally in calm weather, and on sandy shores, and the country people residing near such places train their dogs to catch it. In North Ronaldshay, the northernmost island of the group, a considerable supply is obtained in an original manner: thus described in a letter from a resident inserted in Yarrell's "British Fishes:" "In the winter and early spring, a pair of black-headed gulls take possession of the South Bay, drive away all interlopers, and may be seen at daybreak every morning, beating from side to side, on the wing, and never both in one place, except in the act of crossing as they pass. The sail-fluke skims the ridge of the wave towards the shore with its tail raised over its back, and when the wave recedes is left on the sand, into which it burrows so suddenly and completely that, though I have watched its approach, only once have I succeeded in finding its burrow.

"The gull, however, has a surer eye, and casting like a hawk pounces on the fluke, from which, by one stroke of its bill, it extracts the liver. If not disturbed, the gull no sooner gorges the luscious morsel than it commences dragging the fish to some outlying rock, where he and his consort may discuss it at leisure. By robbing the black backs, I have had the house supplied daily with this excellent fish, in weather during which no fishing-boat could put to sea. Close to the beach of South Bay, a stone wall has been raised to shelter the crops from the sea-spray. Behind this we posted a smart lad, who kept his eye on the soaring gulls. The moment one of the birds made its well-known swoop, the boy rushed to the sea-strand shouting out with all his might. He was usually in time to scare the gull away and secure the fluke, but almost in every case with

the liver torn out. If the gull by chance succeeded in carrying his prey off the rock, he and his partner set up a triumphant cackling, as if deriding the disappointed lad."

The Rays resemble the side-swimmers by the flatness of their form, but differ widely from them in many other particulars. Like the sharks and sturgeons, they belong to the cartilaginous fishes, and as their branchiæ adhere to the cells, these respiratory membranes are not furnished with a gill-cover, but communicate freely with the water by means of five spiracles on either side. More unsightly fishes can hardly be conceived. The rhomboidal broad body, the long narrow tail frequently furnished with two and sometimes three small fins, and mostly armed with one or more rows of sharp spines along its whole length, the dirty colour, and the thick coat of slime with which it is covered, render them pre-eminently disgusting. Their mode of defending themselves is very effectual, and forms a striking contrast to the helplessness of the flat fish. The point of the nose and the base of the tail are bent upwards towards each other, and the upper surface of the body being then concave, the tail is lashed about in all directions over it, and the rows of sharp spines frequently inflict severe wounds.



Thornback.

Eleven species of rays are found on the British coasts, some, like the skates, with a perfectly smooth skin; others, like the thornback, with an upper surface studded with spines, and some, like the sting-ray, with a tail still more powerfully armed with a long serrated spine: a formidable weapon, which the fish strikes with the swiftness of an arrow into its prey or enemy, when with its winding tail it makes the capture secure. The lacerations inflicted by the tropical sting-rays produce the most excruciating tortures. An Indian who accompanied Richard Schomburgk on his travels through Guiana, being hit by one of these fishes while fording a river, tottered to the bank, where he fell upon the ground and rolled about on the sand with compressed lips in an agony of pain. But no tear started from the eye, no cry of anguish issued from the breast, of the stoical savage. An Indian boy wounded in the some manner, but less able to master his emotions, howled fearfully, and flung himself upon the sand,

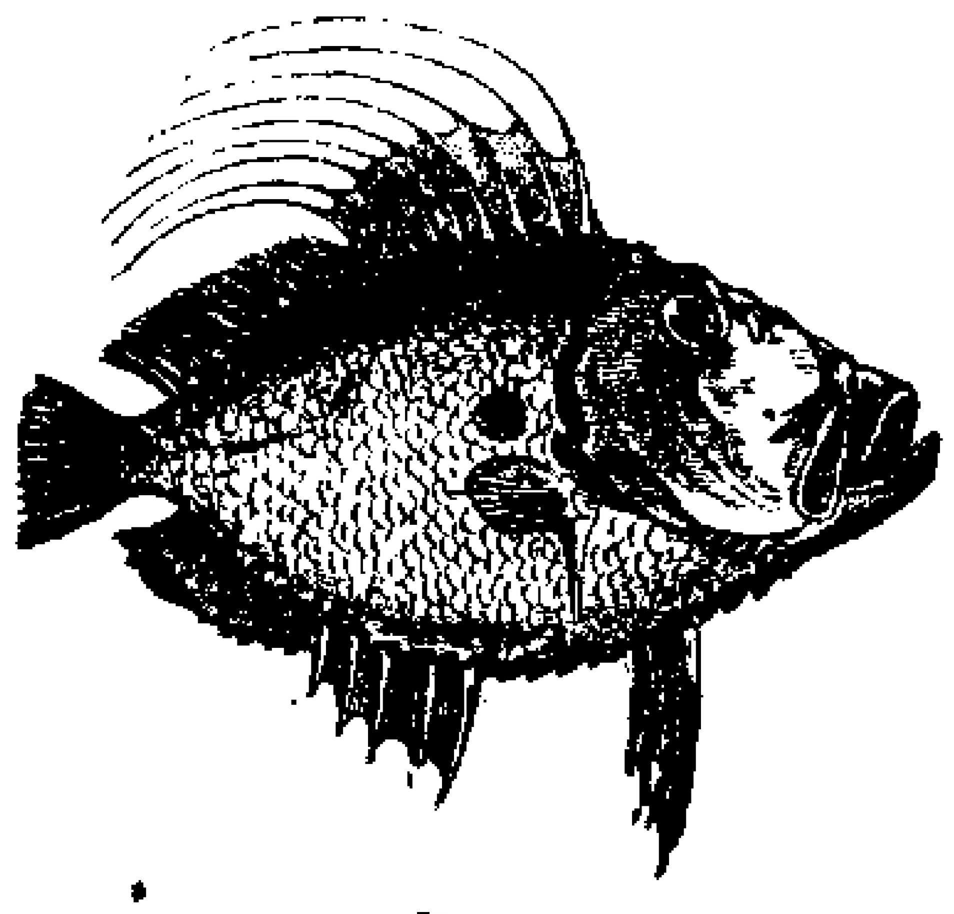
biting it in the paroxysm of his anguish. Although both had been hit in the foot, they felt the severest pain in the loins, in the region of the heart, and in the arm-pits. A robust man, wounded by a sting-ray, died in Demarara under the most dreadful convulsions.

The rays are very voracious; their food consists of any sort of fish, mollusc, annelide, or crustacean, that they can catch. So powerful are their muscles and jaws that they are able to crush the strong shell of a crab with the greatest ease. Even in our seas they attain a considerable size. Thomas Willoughby makes mention of a single skate of two hundred pounds' weight, which was sold in the fish market at Cambridge to the cook of St. John's College, and was found sufficient for the dinner of a society, consisting of more than a hundred and twenty persons. Dr. G. Johnston measured a sharp-nosed ray at Berwick, which was seven feet nine inches long and eight feet three inches broad. But our European rays are far from equalling the colossal dimensions of the sea-devil of the Pacific. This terrific monster swims fast, and often appears on the surface of the ocean, where its black unwieldy back looks like a huge stone projecting above the waters. It attains a breadth of twelve or fifteen feet, and Lesson was presented by a fisherman of Borabora with a tail five feet long. The Society Islanders catch the hideous animal with harpoons, and make use of its rough skin as rasps or files in the manufacture of their wooden utensils.

Creatures so voracious and well armed as the rays would have attained a dangerous supremacy in the maritime domains had they equalled most other fishes in fecundity. Fortunately for their neighbours, they seldom produce more than one young at a time, which, as in the sharks, is enclosed in a four-cornered capsule ending in slender points, but not, as in the former, produced into long filaments.

Thus nature has in this case set bounds to the increase of a race which else might have destroyed the balance of marine existence; in most fishes, however, she has been obliged to provide against the danger of extinction by a prodigal abundance of new germs. If the cod did not annually produce more than nine millions of eggs, and the sturgeon more than seven; if the flat-fish, mackerels, and herrings, did not multiply by

hundreds of thousands, they could not possibly maintain themselves against the vast number of their enemies. "Not one egg too much," every one will say who considers that of all the myriads of germs which are deposited on the shallow sandbanks and shores to be quickened by the fructifying warmth of the sun, not one in a hundred comes to life, as fishes and molluscs, crabs and radiata, devour the spawn with equal voracity; that a thousand dangers await the young defenceless fry, since everywhere in the oceanic realms no other right is known than that of the stronger; and that, finally, the insatiable rapacity of man is continually extirpating millions on millions of the full-grown fishes. But if very few of this much-persecuted race die a natural death, a life of liberty makes them some amends for their violent end. The tortured cart-horse or the imprisoned nightingale would, if they could reflect, willingly exchange their hard lot and joyless existence for the free life of the independent fish, who, from the greater simplicity of his structure, his want of higher sensibilities, his excellent digestion, and the more equal temperature of the element in which he lives, remains unmolested by many of the diseases to which the warm-blooded and particularly the domestic animals are subject.



Dory.

CHAP. XIII.

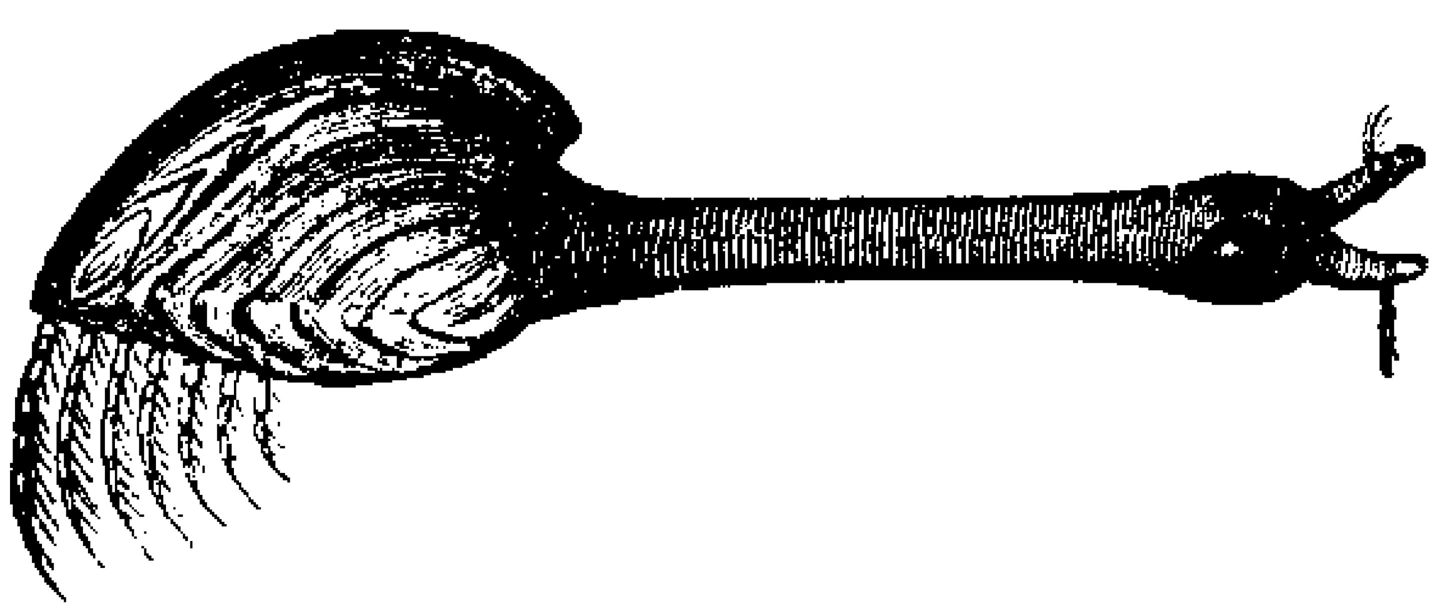
CRUSTACEA.

CRABS—LOBSTERS.

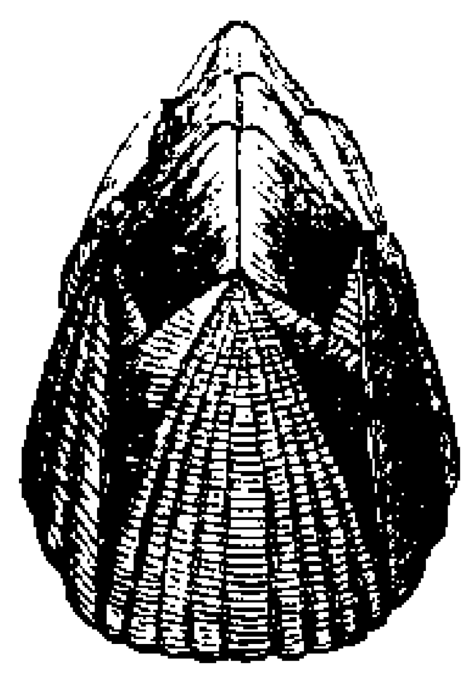
How are they distinguished from the Insects?—Barnacles and Acorn-shells.—Siphonostomata.—Entomostraca.—King-Crab.—Edriophthalmia.—Sandhoppers.—Thoracostraca.—Compound Eye of the higher Crustaceans.—Respiratory Apparatus of the Decapods.—Digestive Organs.—Chelæ or Pincers.—Distribution of Crabs.—Land Crabs.—The Calling Crab.—Modifications of the Legs in different species.—The Pinna and Pinnotheres.—Hermit Crabs.—The Lobster.—The Cocoa-nut Crab.—The Shrimp.—Moulting Process.—Metamorphoses of Crabs.—Victims and Enemies of the Crustaceans—Their Fecundity.—Marine Spiders and Insects.

The Crustaceans were included by Linnæus among his insects, but their internal structure presents such numerous and important differences that modern naturalists have raised them to the dignity of a separate class. They have indeed, in common with the insects, an articulated body, generally cased with hard materials; they are like them provided with jointed legs, with antennæ or feelers, and their organs of mastication are similarly formed; but insects breathe atmospheric air through lateral pores or tracheæ, while the crustaceans, being either aquatic animals or constantly frequenting very damp places, have a branchial or a tegumentary respiration. The perfect insect undergoes no further change; the crustacean, on the contrary, increases in size with every successive year. The higher crustacean possesses a heart, which propels the blood, after it has been aërated in the gills, to every part of the body; in the insect the circulation of the blood is by no means so highly organised. On the other hand many of the insects are far superior in point of intelligence to even the best endowed crustaceans, for here we find no parental care, no mutual affection, no joint labours for the welfare of a large community, no traces of an amiable

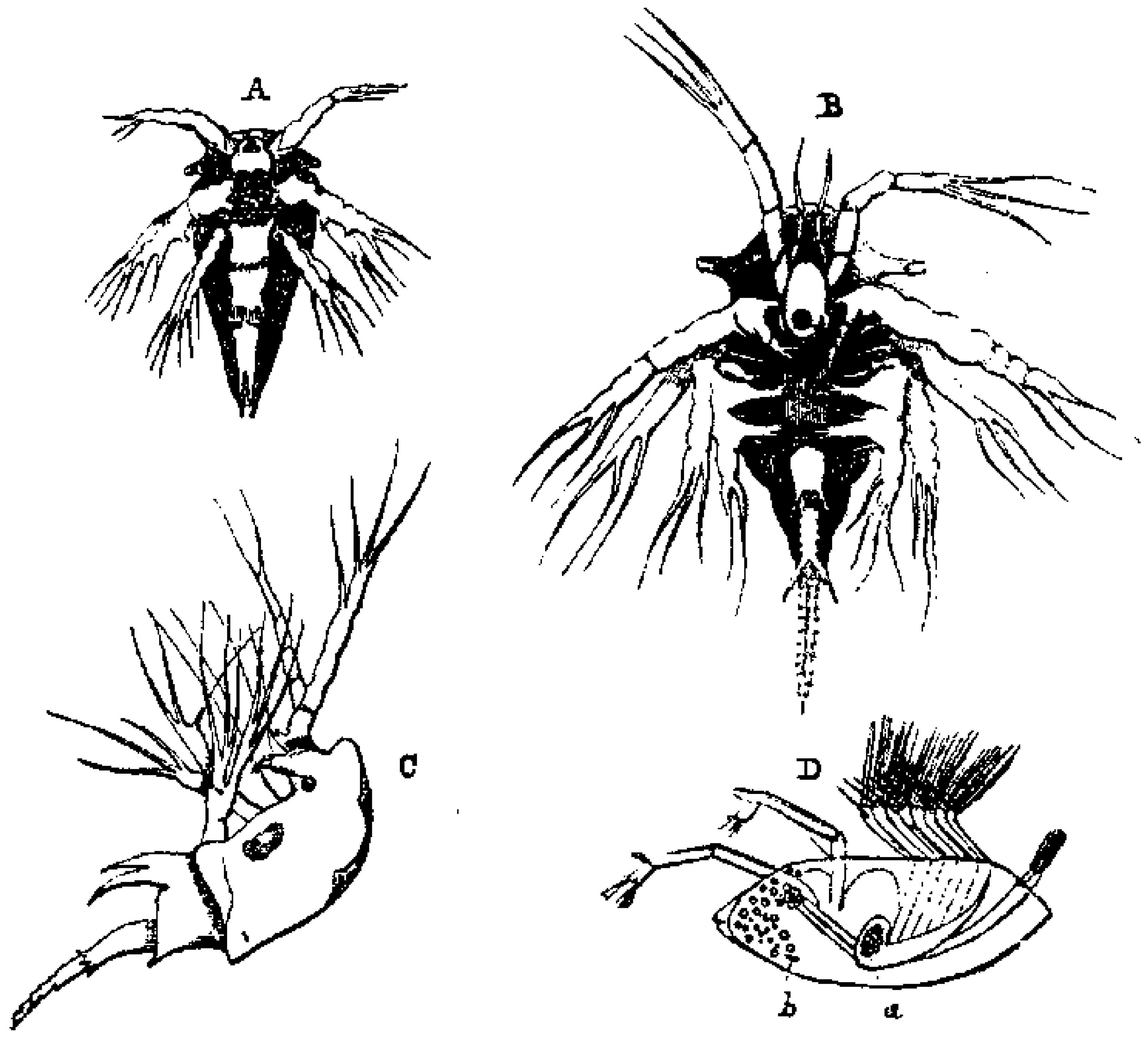
disposition, but frequent outbursts of an irascible and sanguinary temper. Though the whole of the Crustacea are formed after one and the same general type, and the same fundamental idea may be traced throughout all their tribes, yet the rings of which their body is composed, and the limbs or appendages attached to these segments, undergo such extensive modifications of structure in the various orders into which the class has been divided that even the eye of science has with difficulty made out the true nature of many of their lowest forms. Who, for instance, judging from outward appearances alone, would suppose that the Barnacles and Acorn-shells which he sees riveted to the rock or to a piece of floating timber were relations of the crab or lobster; but a view of their early forms at once points out their real character, for then they appear



Barnacle.



Balanus ovularis.



Development of Balanus balanoides.—(Acorn-shell.)

A. Earliest form. B. Larva after second moult. C. Side view of the same. D. Stage immediately preceding the loss of activity. *a*. Stomach. *b*. Nucleus of future attachment.

as active little animals possessing three pairs of legs and a pair of compound eyes, and having the body covered with an expanded

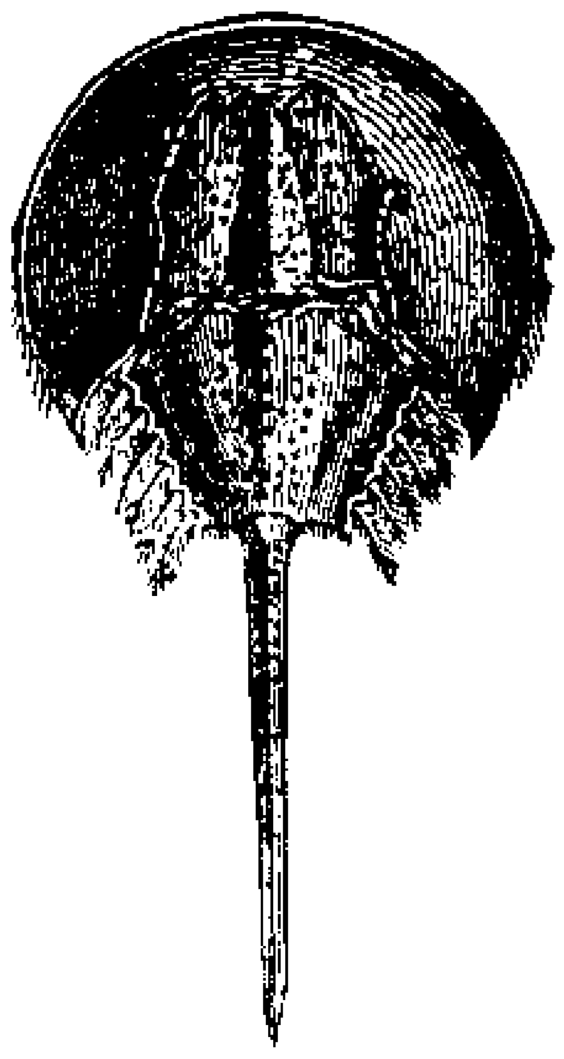
shield like that of many of the lower crustaceans. After going through a series of metamorphoses, these larvæ, tired of a roaming life, attach themselves by their head, a portion of which becomes excessively elongated into the "peduncle" of the Barnacles, whilst in the Balani or acorn-shells it expands into a broad disk of adhesion. The multivalve shell is gradually formed, the eyes are cast away as being no longer needed, and the now useless feet are replaced by six pairs of extremely useful *cirrhi*, long, slender, many-jointed, tendril-like appendages fringed with delicate filaments and covered with vibratile cilia. These cirrhi, which resemble a plume of purple feathers, and from whose peculiar character the name of the group, Cirrhipoda, is derived, are constantly in motion as long as they are bathed in water, projecting outwards and expanding into an oval concave net, then retracting inwards, and closing upon whatever may have come within their reach. They are so judiciously placed that any small animal which becomes entangled within them can rarely escape, and is at once conveyed to the mouth. The currents produced in the water by their perpetual activity serve also to aërate the blood, so that these delicate organs act both as gills and as prehensile arms. In spite of their sessile condition, the Cirrhipeds have not been left without protection against hostile attacks, for at the approach of danger they shrink within their shell, and close its orifice against a host of hungry intruders.

Their various families are widely spread over the seas. It is well known that the barnacles frequently attach themselves in such vast numbers to ships' bottoms as materially to obstruct their way, and the acorn-shells often line the coasts for miles and miles with their large white scurfy patches. The Coronulæ settle so profusely on the skin of the Greenland whale as often to hide the colour of its skin, while the Tubicinellæ exclusively occur on the huge cetaceans of the South Sea. Some of the larger sea-acorns are highly esteemed as articles of food. The Chinese, after eating the animal of *Balanus tintinnabulum* with salt and vinegar, use the shell, which is about two or three inches high and an inch in diameter, as a lamp, and the flesh of *Balanus psittacus* on the southern parts of the South American coast is said to equal in richness and delicacy that of the crab.

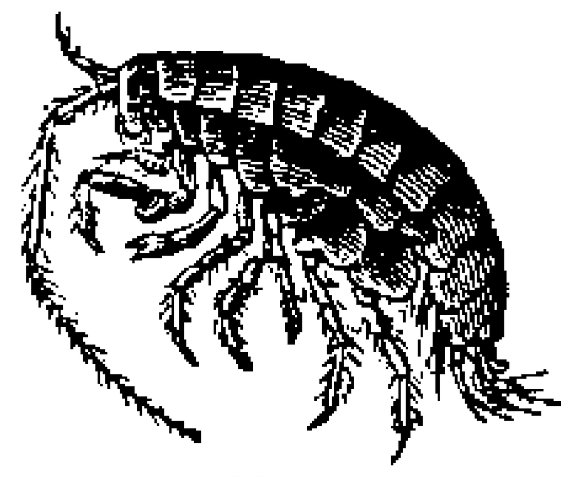
While the Cirrhipeds grasp their prey as in a living net, the Siphonostomata lead a parasitic life chiefly upon fishes, sucking

their juices with a bloodthirsty proboscis. Some (Argulus, Caligus) wander about freely on the body of their victims as grazing animals on their pasture grounds, or even make excursions in the water, where they will turn over and over several times in succession like mountebanks; others (Lerneæ), after having, like the barnacles, indulged in a vagabond existence in their first youth, remain ever after clinging to the spot on which they originally settled, and where their body undergoes such remarkable transformations that not a vestige of the crustacean structure which characterised their erratic life remains.

As we continue to proceed from the lower to the higher forms, we find, on the next stage of crustacean life, the numerous families of the Entomostraca; some bristly-footed (Lophyropoda), with a small number of legs and with respiratory organs attached to the parts in the neighbourhood of the mouth, others gill-footed (Branchiopoda), with numerous foliaceous legs, serving both for respiration and swimming. Some of these creatures, which are generally of such minute size as to be only just visible to the naked eye, have an unprotected body (Branchipus), but generally they are enclosed within a horny or shelly casing, which sometimes closely resembles a bivalve shell in shape and in the mode of junction of its parts, whilst in other instances it forms a kind of buckler, an opening being left behind, through which the members project.

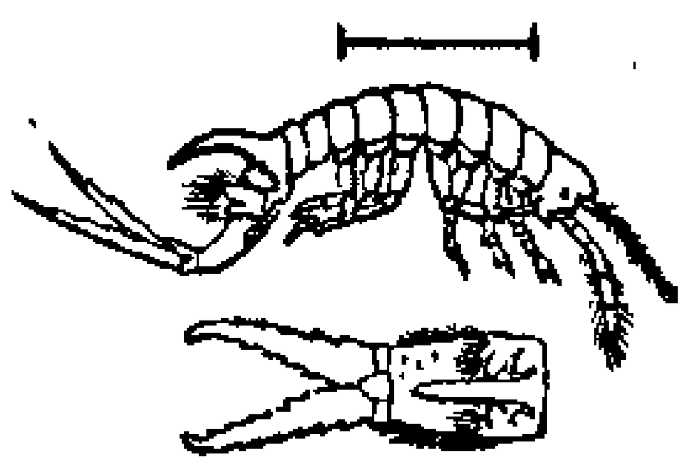

King-Crab.

Though enjoying a royal title, the King-crabs, or Limuli, occupy in reality but a low rank among the crustaceans, and are hardly superior in organisation to the Entomostraca. They are of large size, sometimes attaining the length of two feet, and of a very singular structure, the bases of the legs performing the part of jaws. The best-known species comes from the Moluccas, where they are often seen slowly swimming in the sheltered bays, or still more slowly crawling along upon the sandy shores.

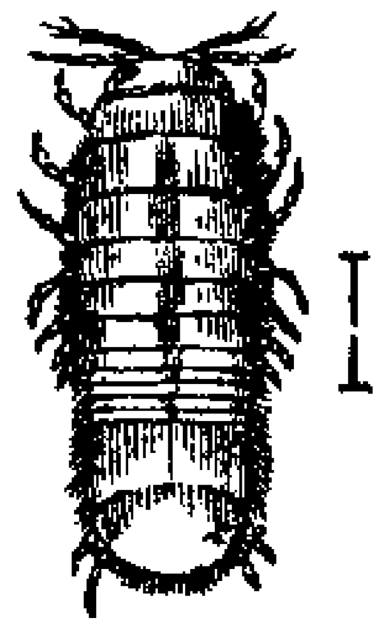

Sandhopper.

In the Edriophthalmia are included the lower crustaceans that have no carapace, and whose thorax and abdomen are distinctly composed of articulated segments. The numerous legs are variously formed in the different genera for springing, walking, or swimming; and respira-

tion is executed by certain portions of the extremities, modified for this purpose in their structure. To this order belong among others the saltatorial sandhoppers (Talitrus), which so frequently jump up before our feet when walking on the wet sea-sand; the ill-famed Cheluræ and Linnoriæ, whose devastations in submerged timber almost rival those of the ship-worm, and the parasitical Cyami, which gnaw deep holes into the skin of the whale. The sandhoppers are extremely frequent on the shores of the arctic seas, where they emulate the tropical ants in their speedy removal of decaying animal substances. Thus Captain Holböll relates that, having enclosed a piece of shark's flesh in a basket, and let it down to a depth of seventy-five fathoms, in the Greenland sea, he by this means caught within two hours six quarts of these little creatures, while a vast number still followed the basket as it was hauled up.



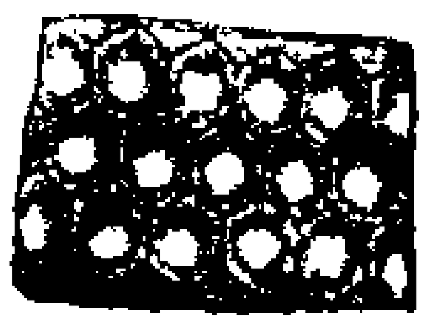
Chelura terebrans.



Limnoria lignorum.

As the lower crustaceans offer but few points of interest to the general reader, they required but a few words of notice; but the highest order of the class, the Thoracostraca, thus named from the carapace which covers their thorax, so that only the abdomen presents an annular structure, may justly claim a more ample description. The preceding orders had either sessile eyes or none at all; here the movable eyes are fixed on stalks and of a compound structure like those of the insects; each ocular globe consisting of a numberof distinct parallel columns, every one of which is provided with its own crystalline lens, receives its separate impression of light, and is thus in itself a perfect eye. Approaches to this structure are seen in some of the lower crustaceans; but here the "ocelli," as these minute individual eyes have been designated, are very numerous. They are at once recognised, under even a low magnifying power, by the facetted appearance of the surface of the compound eye, the facets being either square (Scyllari, &c.) or more commonly hexagonal (Paguri, Squillæ, &c.). The auditory apparatus is likewise highly developed; the sense of smell is known to be very acute; and the antennæ are delicate organs of touch.

Square facets of Scyllarus.



Hexagonal facets of Squilla.

The Thoracostraca are subdivided into the small group of the Stomatopoda, whose branchiæ are external and the feet prehensile or formed for swimming, and the far more numerous and important Decapods, which are either long-tailed like the scyllarus or short-tailed like the crab. In these the branchiæ no longer float in the water, but are enclosed in two chambers, situated one at each side of the under surface of the broad shelly plate which covers the back of the animal. Each of these chambers is provided with two apertures, one in the front near the jaws, the other behind.

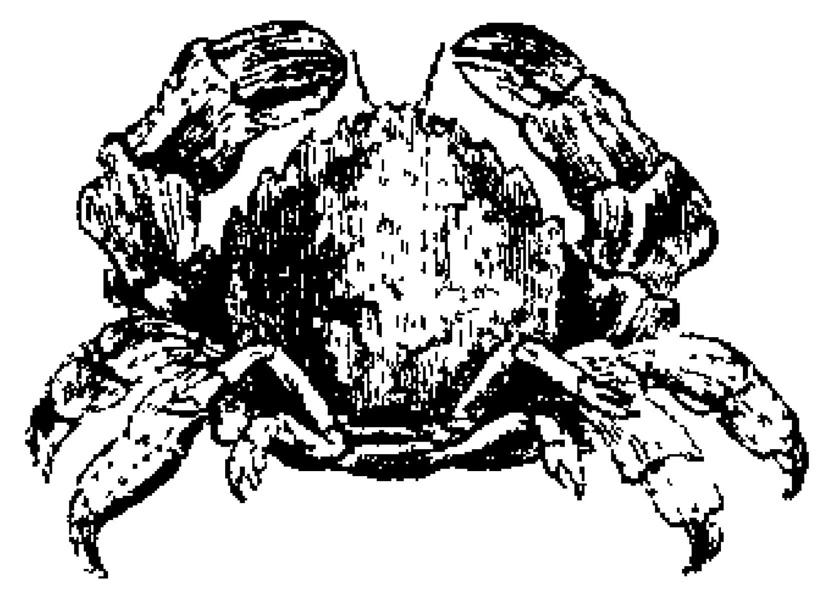
Scyllarus equinoxialis.

The disposition of the anterior or efferent orifice varies but little; but in the long-tailed species the afferent or posterior orifice is a wide slit at the basis of the feet, while in the short-tailed kinds it forms a small transverse aperture generally placed almost immediately in front of the first pair of ambulatory extremities. By means of this formation, the short-tailed decapods or crabs, like those fishes that are provided with a narrow opening to their gill covers, are enabled to exist much longer out of the water than the long-tailed lobsters. Some of them even spend most of their time on land; and, still better to adapt them for a terrestrial life, the internal surfaces of the branchial caverns are lined with a spongy texture, and the gill branches separated from each other by hard partitions, so as to prevent them from collapsing after a long penury of water and thus completely stopping the circulation. While in fishes the water that serves for respiration flows from the front backwards, so as not to impede their motions, we find in the interior of the branchial cavity of the decapods a large valve attached to the second pair of maxillary feet, which, continually falling and rising, occasions a rapid current from behind forwards in the water with which the cavity is filled, a structure perfectly harmonising with their retrograde or sidelong movements.

The digestive apparatus of the decapods is of a very complicated structure. The mouth is here furnished with at least eight pieces or pairs of jaws, which pass the food through an extremely short gullet into a stomach of considerable size. This stomach is rendered curious by having within certain cartilaginous appendages, to which strong grinding-teeth are attached.

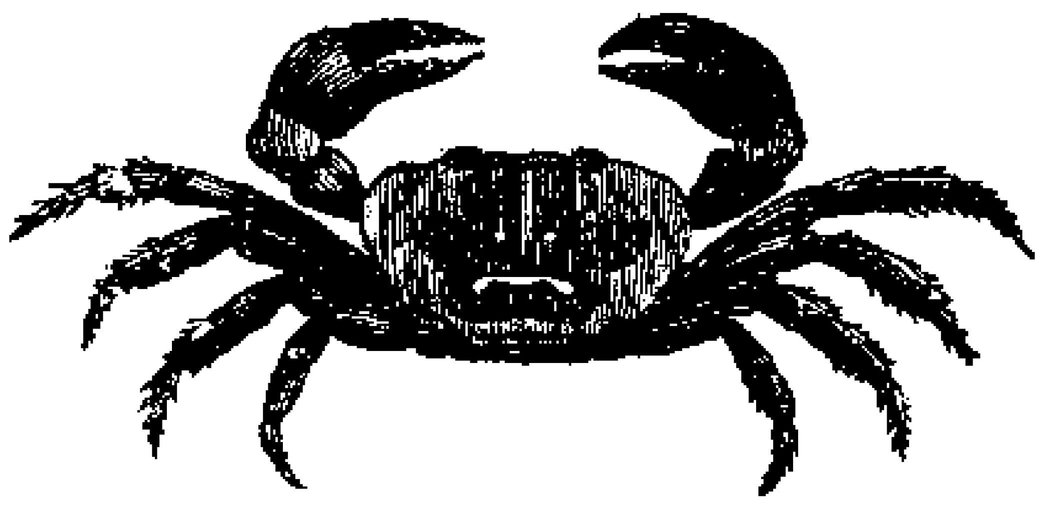
These are placed at the outlet of the stomach, so that the aliment, after being subjected to the action of the jaws, is again more perfectly comminuted by the stomach-teeth before entering the digestive tube. The different pieces composing the masticatory apparatus of the stomach vary considerably in the different genera, and even in the several species of the same genus; but in every case they are always singularly in harmony with the kind of food taken and the general habits of the animal.

To enable the decapods to seize their victims or to defend themselves against their enemies, their anterior thoracic extremities generally assume the form of "chelæ," claws, or pincers of considerable strength, armed with teeth or sharp hooks, which give them increased powers of prehension. This form results mainly from the state of extreme development in which the penultimate articulation frequently occurs, and its assumption of the shape of a finger by the prolongation of one of its inferior angles. Against the finger-like process thus produced, which is of great strength, and quite immovable, the last articulation can be brought to bear with immense force, as it is put into motion by a muscular mass of great size, and in relation with the extraordinary development of the penultimate articulation. In most cases only the first pair of legs is converted into these formidable weapons, but in the Dromiæ, which are very common in the warmer seas, we find the two posterior pairs of legs, which are of a much smaller size, and raised above the plane of the others, similarly armed. These posterior claws, however, are not intended for active warfare, but merely for strategical purposes, as they serve to hold fast the pieces of sponges, shells, medusæ, and other marine productions, under whose cover the wily robber approaches and entraps his prey.

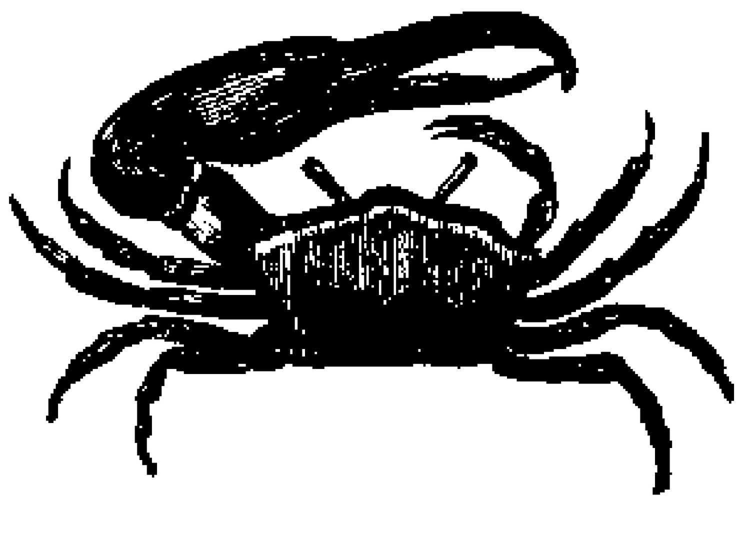

Dromia Vulgaris.

While the lower crustaceans abound in the polar seas, the crabs are completely wanting in those desolate regions; their number increases with the warmer temperature of the waters, and attains its maximum in the tropical zone. Here we find the most remarkable and various forms, here they attain a size unknown in our seas: and

here they do not, as with us, inhabit solely the salt waters, but also people the brooks and rivers, or even constantly sojourn on land,—as, for instance, the *Thelphusæ* and *Gecarcini*. There are even some species of land-crabs that suffocate when dipped into water. They breathe indeed through branchiæ, but the small quantity of oxygen dissolved in water does not suffice for the wants of their active respiration. They generally live in the shades of the damp forests, often at a great distance from the sea, concealing themselves in holes. At breeding time they generally seek the shore for the purpose of washing off their spawn, and depositing it in the sand, and no obstruction will then make them deviate from the straight path. They feed on vegetable substances, and are reckoned very excellent food. When taken, they will seize the person's finger with their claw, and endeavour to escape, leaving the claw behind, which for some time after it has been separated from the body, continues to give the finger a friendly squeeze. In the dusk of the evening they quit their holes, and may then be seen running about with great swiftness.

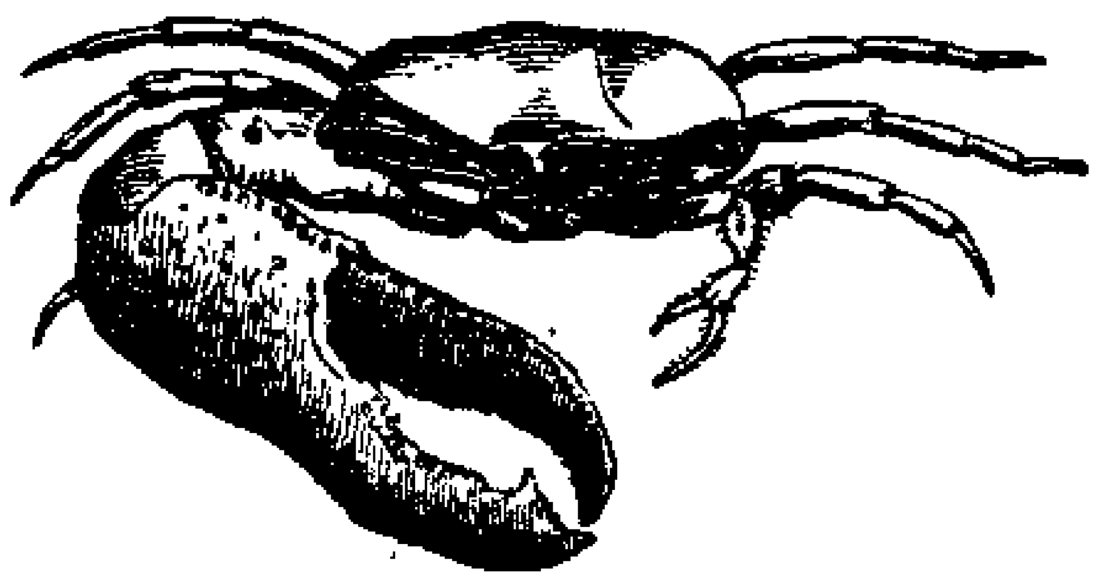

Jamaica Land-Crab.

All sandy and muddy coasts of the tropical seas, affording sufficient protection against a heavy sea, swarm with crabs. In the East and West Indies the Gelasimi bore in every direction circular holes in the moist black soil of the coast. One of the claws of these remarkable creatures is much larger than the other, so as sometimes to surpass in size the whole remainder of the body. They make use of it as a door, to close the entrance of their dwelling, and when running swiftly along, carry it upright over the head, so that it seems to beckon like an outstretched hand. One might fancy the crab moved it as in derision of its pursuers, telling them by pantomimic signs, "Catch me if you can!"


Large-Clawed Calling-Crab.

As soon as the ebbing flood lays bare the swampy grounds of the mangrove woods, myriads of animals are seen wallowing in the pestiferous mud. Here a fish jumps about, there a holothuria crawls, and crabs run along by thousands in every direc-

tion. The black mud along the coast of Borneo assumes quite a brilliant blue tinge, when, at low water, during the heat of the day, the cœrulean Gelasimi come forth to feed.



Calling-Crab of Ceylon.

The Venetian lagoons also harbour a vast number of the common Shore-Crab (*Portunus Mœnas*), the catching of which affords a profitable employment to the inhabitants of those swampy regions. Whole cargoes are sent to Istria, where they are used as bait for anchovies. The fishermen gather them a short time before they cast their shell, and preserve them in baskets, until the moulting process has been effected, when they are reckoned a delicacy even on the best tables. On attempting to seize this crab, it runs rapidly sideways, and conceals itself in the mud; but when unsuccessful, it raises itself with a menacing mien, beats its claws noisily together, as if in defiance of the enemy, and prepares for a valiant defence, like a true knight.

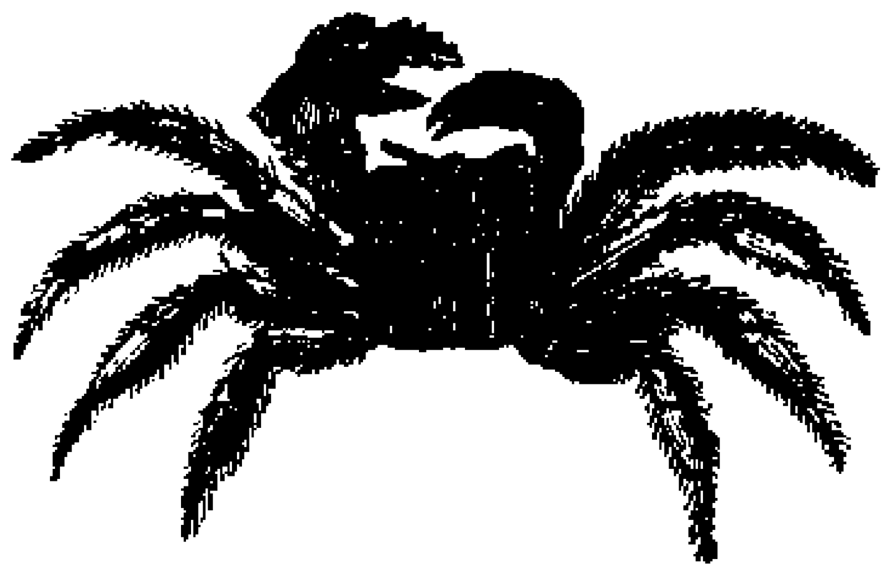
The most valuable short-tailed crustacean of the North Sea is undoubtedly the Great Crab (*Cancer pagurus*), which attains a weight of from four to five pounds, and is consumed by thousands in the summer, when it is in season and heaviest. It is caught in wicker-baskets, arranged so as to permit an easy entrance, while egress is not to be thought of.

The legs of the crabs are very differently formed in various species. In those which have been called sea-spiders they are very long, thin, and weak, so that the animal swims badly, and is a slow and uncertain pedestrian. For greater security it therefore generally seeks a greater depth, where, concealed among the seaweeds, it wages war with annelides, planarias, and small mollusks Sea-spiders are often found on the oyster-banks, and considered injurious by the fishermen, who unmercifully destroy them whenever they get hold of them.

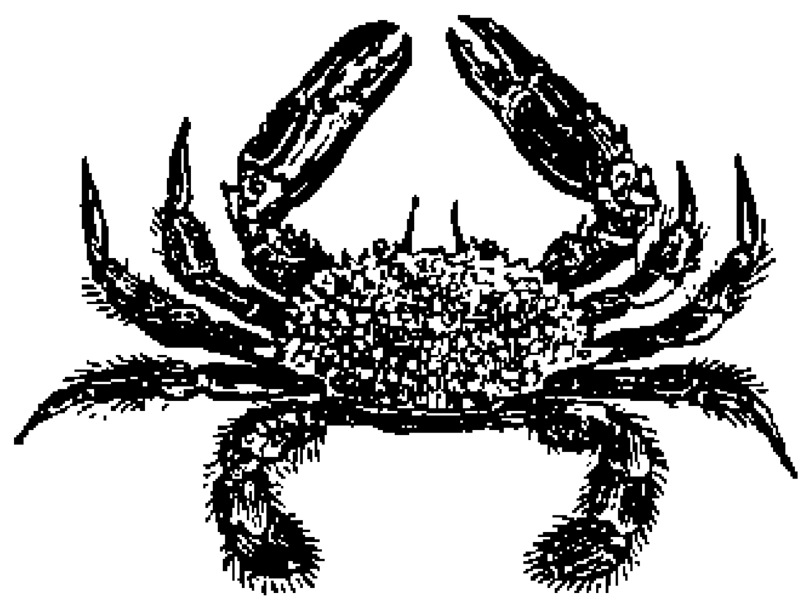
In other species the legs are short, muscular, and powerful, so as rapidly to carry along the comparatively light body. The tropical land-crabs and the genera *Ocypoda* and *Grapsus*, which form the link between the former and the real sea-crabs, are particularly distinguished in this respect.

The Rider or Racer (*Ocypoda cursor*), who is found on the

coasts of Syria and Barbary, and abounds at Cape de Verde, owes his name to his swiftness, which is such that even a man on horseback is said not to be able to overtake him. The West Indian ocypodas dig holes three or four feet deep, immediately above high-water mark, and leave them after dusk. Towards the end of October they retire further inland, and bury themselves for the winter in similar holes, the opening of which they carefully conceal.


American Sand-Crab.

In the Portuni, or true Sea-crabs, finally, we find the hind pair of legs flattened like fins, so that they would cut but a sorry figure on the land, but are all the better able to row about in their congenial element.

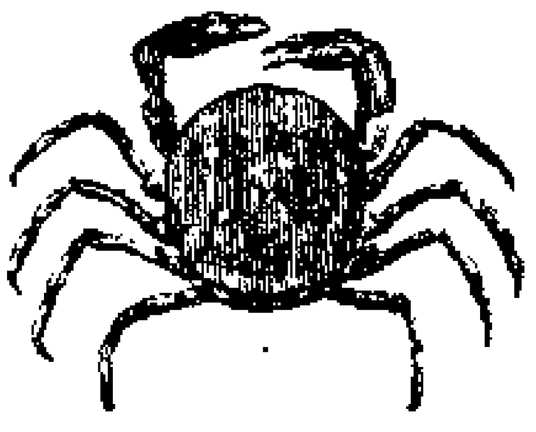

Spotted Fin-Crab.

A strange peculiarity of many crabs is the quantity of parasites they carry along with them on their backs. Many marine productions, both of a vegetable and animal nature, have their birth and grow to beauty on the shell of the sea-spider. Corallines, sponges, zoophytes, algæ, may thus be found, and balani occasionally cover the entire upper surface of the body of the crab. "All the examples of the *Inachus Dorsettensis* which I have taken," says the distinguished naturalist, Mr. W. Thompson of Belfast, "were invested with sponge, which generally covers over the body, arms, and legs; algæ and zoophytes likewise spring from it." In this extraneous matter some of the smaller zoophytes find shelter, and, together with the other objects, render the capture of the *Inachus Dorsettensis* interesting far beyond its own acquisition. In Mr. Hyndman's collection, there is a sea-spider carrying on its back an oyster much larger than itself, and covered besides with numerous barnacles. Like Atlas, the poor creature groaned under a world.

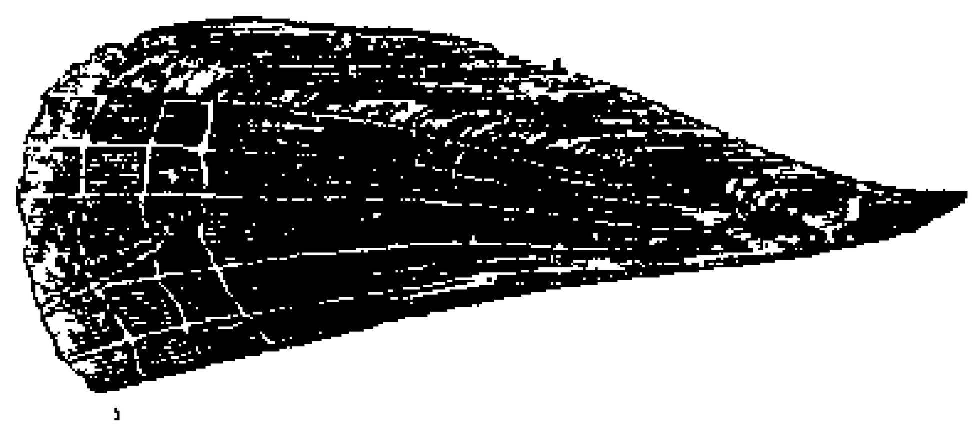
The extraneous matters which so many crabs carry along with them are, however, far from being always a useless burden; they are often a warlike stratagem, under cover of which the sly crustacean entraps many a choice morsel. Thus Bennett witnessed at Otaheite the proceedings of an interesting Hyas

species, which disguised itself by investing its body with a covering of decayed vegetable substances and coral-sand. The better to ensnare its prey, the back was covered with rigid and incurved bristles, calculated to retain the extraneous substances, while the short and well concealed forceps-claws were ready for the attack, and the ophthalmic peduncles, curving upward to raise the eyes above the pile of materials, gave the wily crab the great advantage of seeing without being seen. As soon as an unfortunate mollusk, unsuspicious of evil, approached the lurking ruffian, he darted upon it like an arrow, and, ere it could recover its presence of mind, was busy tearing it to pieces.

If many crabs are burdened with small animals and plants, others live parasitically in the shells of mollusks. Thus the small *Pinnotheres veterum* claims the hospitality of the Pinna, a large bivalve of the Mediterranean. The ancients supposed that this was a friendly connection, an *entente cordiale*, formed for mutual defence: that the Pinna, being destitute of eyes, and thus exposed when he opened his shell to the attacks of the cuttle-fish and other enemies, was warned of their approach by his little lodger, upon which he immediately closed his shell and both were safe. Unfortunately, there is not a word of truth in the whole story. The sole reason why the Pinnotheres takes up its abode under a stranger's roof is the softness of its own integuments, which otherwise would leave it utterly defenceless; nor does the Pinna show the least sign of affection for its guest, who, on returning from an excursion, often finds it very difficult to slip again into the shell.



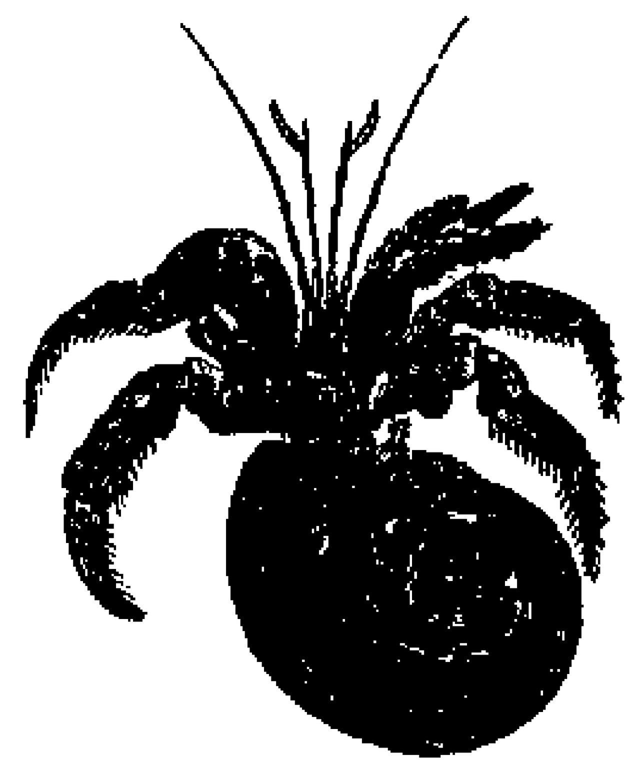
Pea-Crab.



Pinna Augustana.

According to Mr. Thompson, the *Modiola vulgaris*, a species of mussel very common on the Irish coast, almost always harbours several parasitic crabs (*Pinnotheres pisum*). At Heligoland, Dr. Oetker, to whom we are indebted for the best work on that interesting island, scarce ever found a modiola without several guests of this description, while he never could find any in oysters, mussels, and other nearly related species. What may the reason be of either this predilection or that desertion?

The numerous family of the Paguri, or Hermit crabs, is also condemned by its formation to lead a parasitic and robber-life. The fore part of the body is indeed, as in other crabs, armed with claws and covered with a shield, but ends in a long soft tail provided with one or two small hooks. How then are the poor creatures to help themselves? The hind part is not formed for swimming, and its weight prevents them from running. Thus nothing remains for them but to look about them for some shelter, and this is afforded them by several conchiform shells, *buccina*, *neritæ*, in which they so tenaciously insert their hooked tails, as it both were grown together. So long as they are young and feeble, they content themselves with such shells as they find empty on the strand, but when grown to maturity, they attack living specimens, seize with their sharp claws the snail, ere it can withdraw into its shell, and after devouring its flesh, creep without ceremony into the conquered dwelling, which fits them like a coat when they take a walk, and the mouth of which they close when at rest with their largest forceps, in the same manner as the original possessor used his operculum or lid. How remarkable that an animal should thus find in another creature belonging to a totally different class, the completion, as it were, of its being, and be indebted to it for the protecting cover which its own skin is unable to secrete!


Diogenes Hermit Crab.

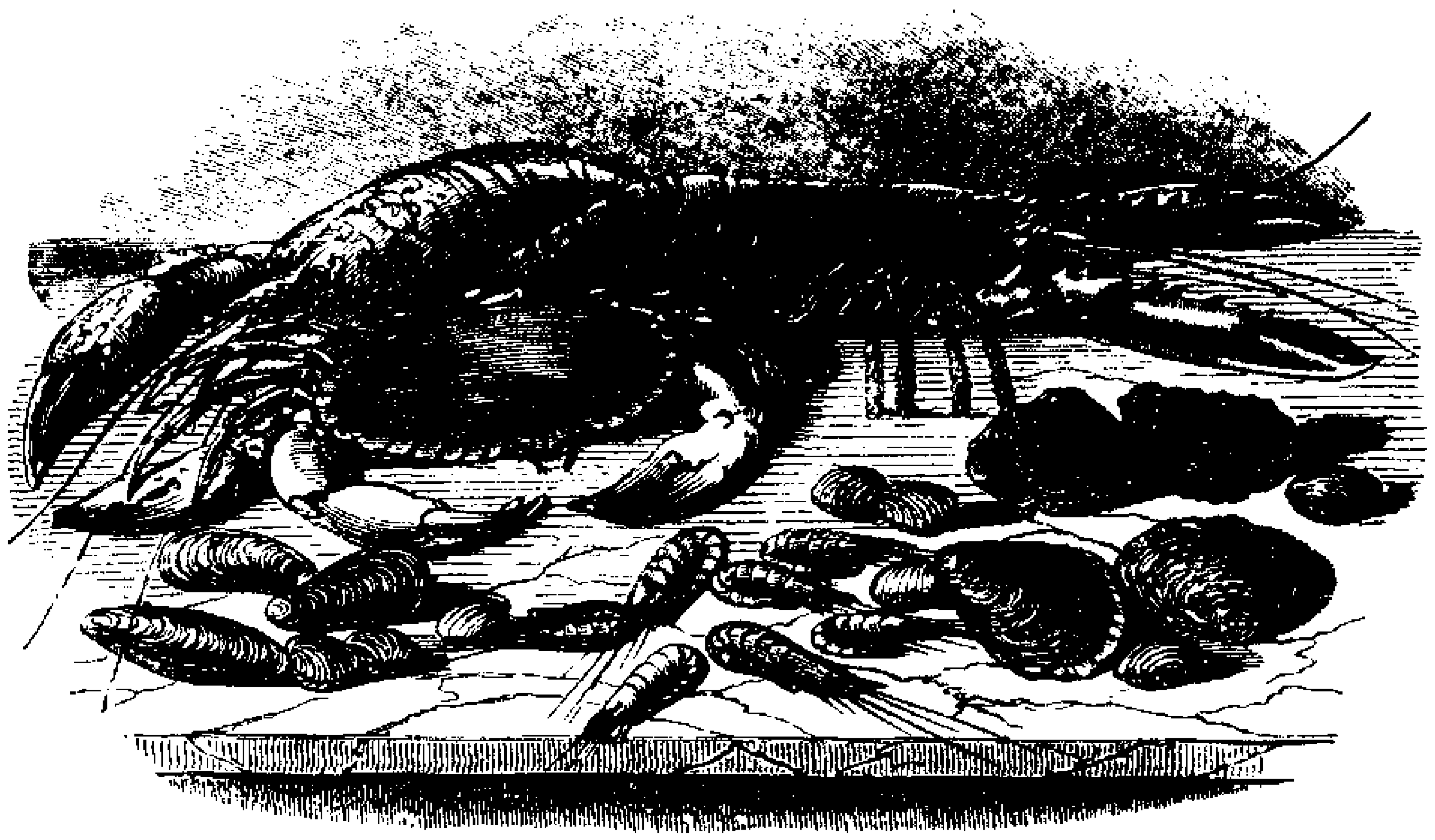
When the dwelling of the pagurus becomes inconveniently narrow, the remedy is easy, for appropriate sea-shells abound wherever hermit crabs exist. They are found on almost every coast, and every new scientific voyage makes us acquainted with new species. According to Quoy and Gaimard, they are particularly numerous at the Ladrones, New Guinea, and Timor. The strand of the small island of Kewa, in Coupang Bay, was entirely covered with them. In the heat of the day they seek the shade of the bushes; but as soon as the cool of evening approaches, they come forth by thousands. Although they make all large snail-houses answer their purposes, they seem in this locality to prefer the large Sea Nerites.

The famous East Indian Cocoa-nut Crab (*Birgus latro*), a kind of intermediate link between the short and long tailed

crabs, bears a great resemblance to the paguri. It is said to climb the palm-trees, for the sake of detaching the heavy nuts; but Mr. Darwin, who attentively observed the animal on the Keeling Islands, tells us that it merely lives upon those that spontaneously fall from the tree. To extract its nourishment from the hard case, it shows an ingenuity which is one of the most wonderful instances of animal instinct. It must first of all be remarked, that its front pair of legs is terminated by very strong and heavy pincers, the last pair by others, narrow and weak. After having selected a nut fit for its dinner, the crab begins its operations by tearing the husk, fibre by fibre, from that end under which the three eye-holes are situated; it then hammers upon one of them with its heavy claws, until an opening is made. Hereupon it turns round, and by the aid of its posterior pincers, extracts the white albuminous substance. It inhabits deep burrows, where it accumulates surprising quantities of picked fibres of cocoa-nut husks, on which it rests as on a bed. Its habits are diurnal; but every night it is said to pay a visit to the sea, no doubt for the purpose of moistening its branchiæ. It is very good to eat, living as it does on choice vegetable substances; and the great mass of fat, accumulated under the tail of the larger ones, sometimes yields, when melted, as much as a quart of limpid oil. Thus our taking possession of the Keeling Islands, as a coaling station for the steamers from Australia to Ceylon, bodes no good to the Birgus.

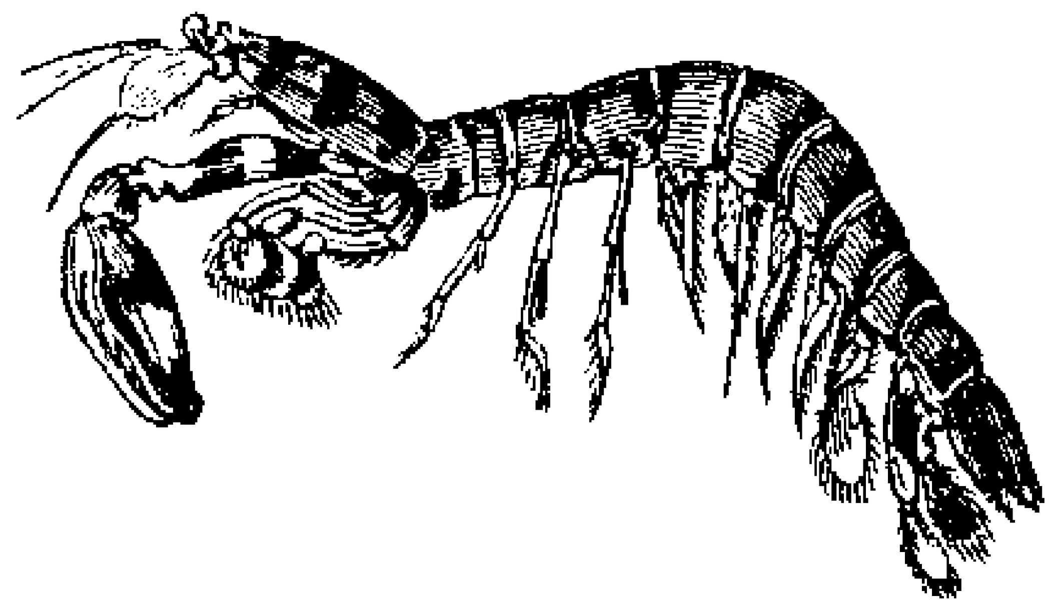
The long tail, which the paguri sedulously conceal in shells, serves the shrimps and lobsters as their chief organ of locomotion, for although these creatures have well-formed legs, they make but slow work of it when they attempt to crawl. But nothing can equal the rapidity with which they dart backwards through the water, by suddenly contracting their tail. Thus the Lobster makes leaps of twenty feet at one single bound, and the little shrimp equals it fully in velocity in proportion to its size, and belongs unquestionably to the most active of the denizens of the ocean. It swarms in incalculable numbers on the sandy shores of the North Sea, where it is caught in nets attached to a long cross pole, which the fishermen, walking-knee deep in the water, push along before them. Boiled shrimps are a well known delicacy; and the *Squilla Mantis* of the Mediterranean, which resembles our common shrimp in outer form, but essen-

tially differs from it in the formation of its branchiæ, which float freely in the water, attached to the abdominal legs, holds an equal rank in the estimation of the South Europeans.



Crustaceans and Oysters.

But of all crustaceans, none approaches the Lobster in delicacy of taste. This creature, the epicure's delight, loves to dwell in the deep clear waters along bold rocky shores, where it is taken in wicker baskets, or with small nets attached to iron hoops. About two millions of lobsters are annually imported from Norway, although they are also found in great abundance along the Scottish and Irish coasts. Thus, considering their high price, they form a considerable article of trade; and yet they are far from equalling in importance the minute Herring-crab (*Cancer halecum*), which, by forming the chief nourishment of that invaluable fish, renders in an indirect way incalculable services to man.



Spotted Mantis Crab.

The lobster breeds in the summer months, depositing many thousands of eggs in the sand, and leaving them there to be hatched by the sun. But few, as may easily be imagined, live to attain a size befitting them to appear in red livery on our tables. Like all crustaceans, the lobster casts its shell annually, and with such perfection, that the discarded garment, with all

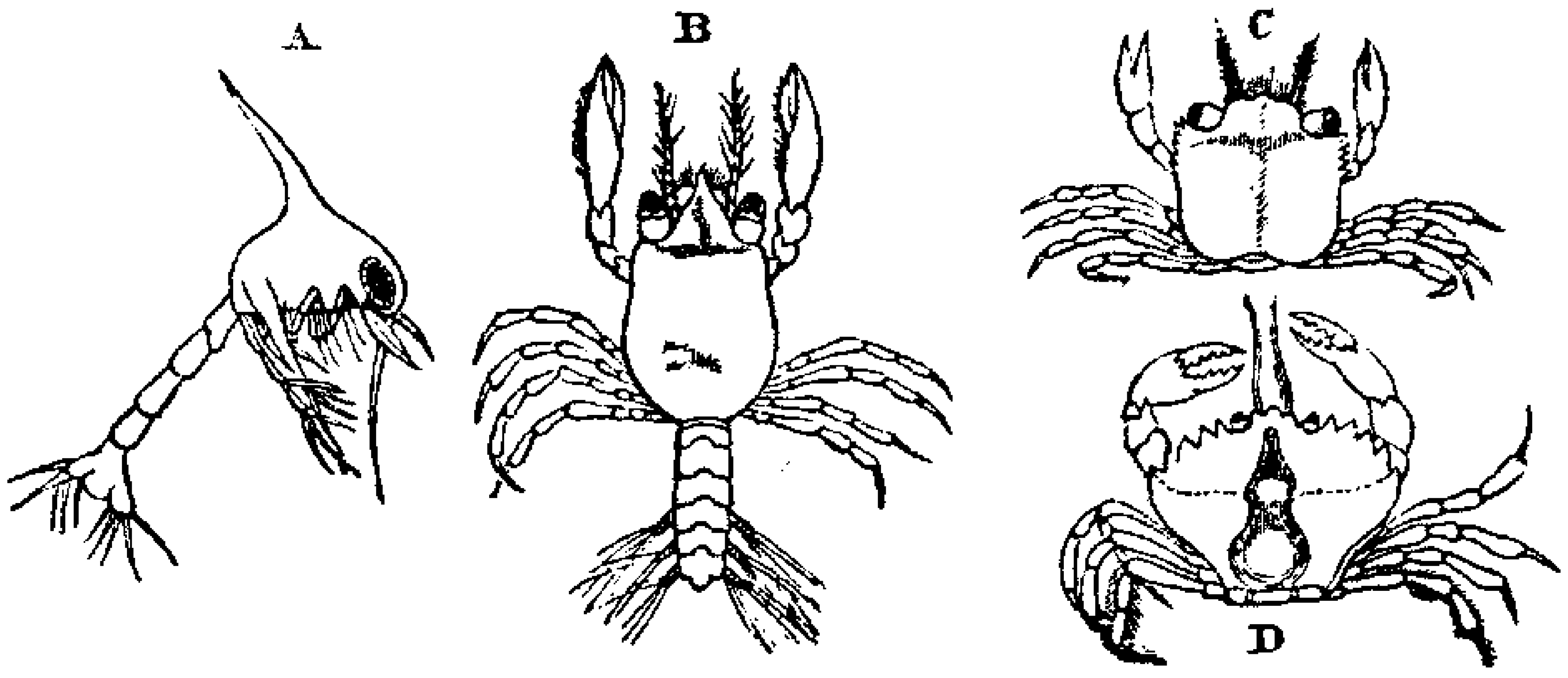
its appendages, perfectly resembles the living animal. The process is curious enough to deserve a few lines of description.

When towards autumn, the time of casting the shell approaches, the lobster retires to a silent nook, like a pious hermit to his cell, and fasts several days. The shell thus detaches itself gradually from the emaciated body, and a new and tender cuticle forms underneath. The old dress seems now, however, to plague the lobster very much, to judge by the efforts he makes to sever all remaining connection with it. Soon the harness splits right through the back, like the cleft bark of a tree, or a ripe seed-husk, and opens a wide gate to liberty. After much tugging and wriggling, the legs, tail, and claws gradually follow the body. The claws give the lobster most trouble; but he is well aware that perseverance generally wins the day, and never ceases till the elastic mass, which can be drawn out like india-rubber, and instantly resumes its ordinary shape, has been forced through the narrow passage. It can easily be supposed that, after such a violent struggle for freedom, the lobster is not a little exhausted. Feeling his weakness, and the very insufficient protection afforded him by his soft covering, he bashfully retires from all society until his hardened case allows him to mix again with his friends on terms of equality, for he well knows how inclined they are to bite and devour a softer brother.

The facility with which the crustacea cast off their legs, and even their heavy claws, when they have been wounded in one of these organs or alarmed at thunder, is most remarkable Without the least appearance of pain, they then continue to run along upon their remaining legs. After some time a new limb grows out of the old stump, but never attains the size of the original limb.

At the beginning of the chapter I have already briefly described the wonderful transformations of the barnacles, acorn-shells, and lerneæ, but the changes which the young crabs, lobsters, prawns, and shrimps, have to undergo ere they assume their perfect form are no less astonishing. Thus in the earliest state of the small edible crab (*Carcinus mœnas*) we find a creature with a preposterously large helmet-shaped head, ending behind in a long spine, and furnished in front with two monstrous sessile eyes like the windows of a lantern. By means

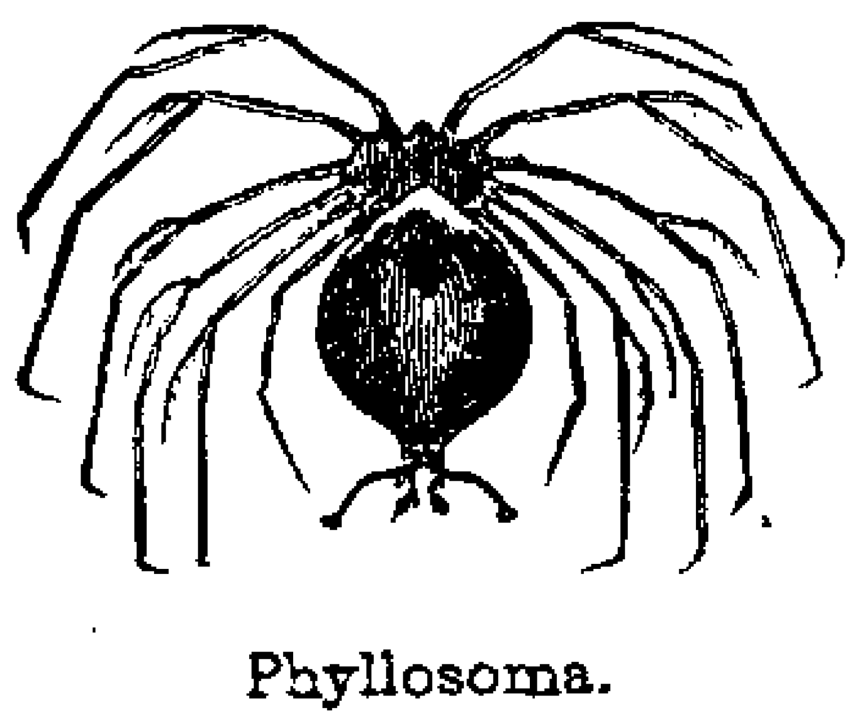
of a long articulated tail the restless Chimera continually turns head over heels. Claws are wanting, and while the old crab is of course a perfect decapod, the young has only four bifid legs, armed at the extremity with four long bristles, that are con-



Metamorphosis of Carcinus mœnas.

A. First stage. B. Second stage. C. Third stage, in which it begins to assume the adult form. D. Perfect form.

tinually pushing food towards the ciliated mouth. Who could imagine that a creature like this should ever change into a crab, to which it has not the least resemblance? But time does wonders. After the first change of skin the body assumes something like its permanent shape, the eyes become stalked, the claws are developed, and the legs resemble those of the crab, but the tail is still long, and the swimming habit has not yet been laid aside. At the next stage, while the little creature is still about the eighth of an inch in diameter, the crab form is at length completed, the abdomen folding in under the carapace. No wonder that these larvæ were long supposed to be distinct types, and described under the names of Zoëa and Megalops, until Mr. T. J. Thompson first discovered their real nature.



Phyllosoma.

The life history of the Palinuri or spiny lobsters is equally curious. They frequently weigh ten or twelve pounds each, and are distinguished by the very large size of their lateral antennæ and by their feet being unarmed with pincers. Surely nothing can be more dissimilar than the glass crabs or

Phyllosomas, thin as a leaf of paper, and so transparent that their blue eyes are their only visible parts while swimming in the water; and yet these flimsy creatures are nothing but the young of the large and bulky Palinuri.

Though several of the lower crustaceans ascend into the regions of eternal snow, while others hide themselves in the perpetual night of subterranean grottoes; though many delight in the sweet waters of the river or the lake, or rapidly multiply in stagnant pools, yet the chief seat of their class, which altogether comprises about 1,600 known species, is in the ocean and its littoral zone, where their numbers, their voracity, and their powerful claws, render them the most formidable enemies of all the lower aquatic animals that are not swift or cunning enough to escape them. Even the fishes and cetaceans are, as we have seen, exposed to their attacks; and as the whale, the carp, the sturgeon, the shark, the perch, have each of them their peculiar crustacean parasites, it can easily be imagined how large the number of still unknown species must be which feast on that vast host of fishes that has never yet been accurately examined. On the other hand, the crustaceans constitute a great part of the food, as well of the sea-stars, sea-urchins, annelides, and many of the molluscs, as also of the fishes and sea-birds; and as they are found of all sizes, from microscopical minuteness to the gigantic proportions of the *Inachus Kœmpferi* of Japan, the fore-arm of which measures four feet in length, and the others in proportion, so that it covers about 25 feet square of ground, they are able to satisfy the wants or the voracity of a vast number of enemies, from the rotifer or the polyp that feed on tiny entomostraca or the larvæ of the barnacle, to man, who selects a great variety of the fat and luscious decapods for his share of the feast.

A great fecundity enables the crustaceans to bear up against all these persecutions. 12,000 eggs have been found on the lobster; 6,807 on the shrimp; 21,699 on the great crab (*Platycarcinus pagurus*). The lower orders are still more prolific, for such is the rapidity with which many of them come to maturity and begin to propagate that it has been calculated that a single female Cyclops may be the progenitor in one year of 4,442,189,120 young! Endowed with such powers, the

crustaceans are not likely to be extirpated, nor to disappoint the hopes of their gastronomical admirers for many an age to come.

When we hear of fishes wandering about on the dry land, we cannot wonder that some insects and arachnidans should depart so strangely from the usual habits of their class as to select the sea for their habitation.

"There is a minute marine spider," says Mr. Gosse, "very common on most parts of the coast, crawling sluggishly upon the smaller sea-weeds, which seems, from its lack of centralisation, to realise our infant ideas of Mr. Nobody; but zoologists have designated him as *Nymphon gracile.* Widely different from the spiders of terra firma, in which an abdomen some ten times as bulky as all the rest of the animal put together is the most characteristic feature, the belly of our marine friend is reduced to an atom not so big as a single joint of one of his eight legs; though his thorax is more considerable, this is little more than the extended line formed by the successive points of union of the said legs. These latter, on the other hand, are long, stout, well-armed, and many-jointed; but, apparently from the lack of the centralising principle, they are moved heavily, sprawled hither and thither, and dragged about like the limbs of an unfortunate who is afflicted with the gout." This strange little creature has four eyes gleaming like diamonds, respires by the skin, and its stomach is prolonged into each of its eight legs, which are thus made the seats of digestion. Mr. Nobody and his marine relations, some of which also attach themselves to fishes, form the small group of the *Pycnogonida* (πυκνός, *frequent*; γόνυ, *knee*) thus named from their many-jointed legs.

It is a well-known fact that the winds will sometimes waft butterflies to an immense distance from the shore. Thus *Acherontia atropos* has been found on the Atlantic a thousand miles from the nearest land; and while Mr. Darwin was in the bay of San Blas, in Patagonia, he saw thousands of butterflies hovering over the sea as far as the eye could reach. These insects, of course, are nothing but stray wanderers on an alien and hostile element; but *Leptopus longipes,* a species of

bug, makes the salt water its home; the Halobates, another hemipterous insect, faces the tranquil mirror of the tropical seas as leisurely as our water-bugs sport on the glassy surface of our ponds, and the *Gyrinus marinus*, a beetle belonging to the family of the whirligigs, ambitiously seeks a wide expanse, and may be seen curvetting about on the surface of the sea, and darting down every now and then to seize its prey.

Stenopus hispidus

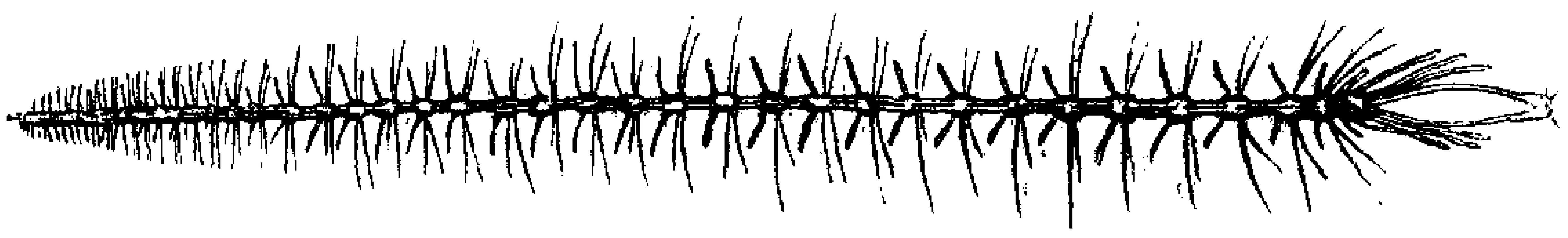
CHAP. XIV.

MARINE ANNELIDES.

The Annelides in general.—The Eunice sanguinea.—Beauty of the Marine Annelides.—The Giant Nemertes.—The Food and Enemies of the Annelides.—The Tubicole Annelides. — The Rotifera — Their Wonderful Organisation.— The Synchæta Baltica.

The class of the Annelides, or annulated worms — to which also our common earth-worm and the leech belong — peoples the seas with by far the greater number of its genera and species. All of them are distinguished by an elongated, and generally worm-like form of body, susceptible of great extension and contraction. The body consists of a series of rings, or segments, joined by a common elastic skin; and each ring, with the exception of the first or foremost, which forms the head, and the last which constitutes the tail, exactly resembles the others, only that the rings in the middle part of the body are larger than those at the extremities. The head is frequently provided with eyes, and more or less perfect feelers; the mouth is armed in many species with strong jaws, or incisive teeth. The blood is red, and circulates in a system of arteries and veins.

With the idea of a worm we generally connect that of incompleteness; we are apt to consider them as beings equally uninteresting and ugly, and disdain to enquire into the wonders

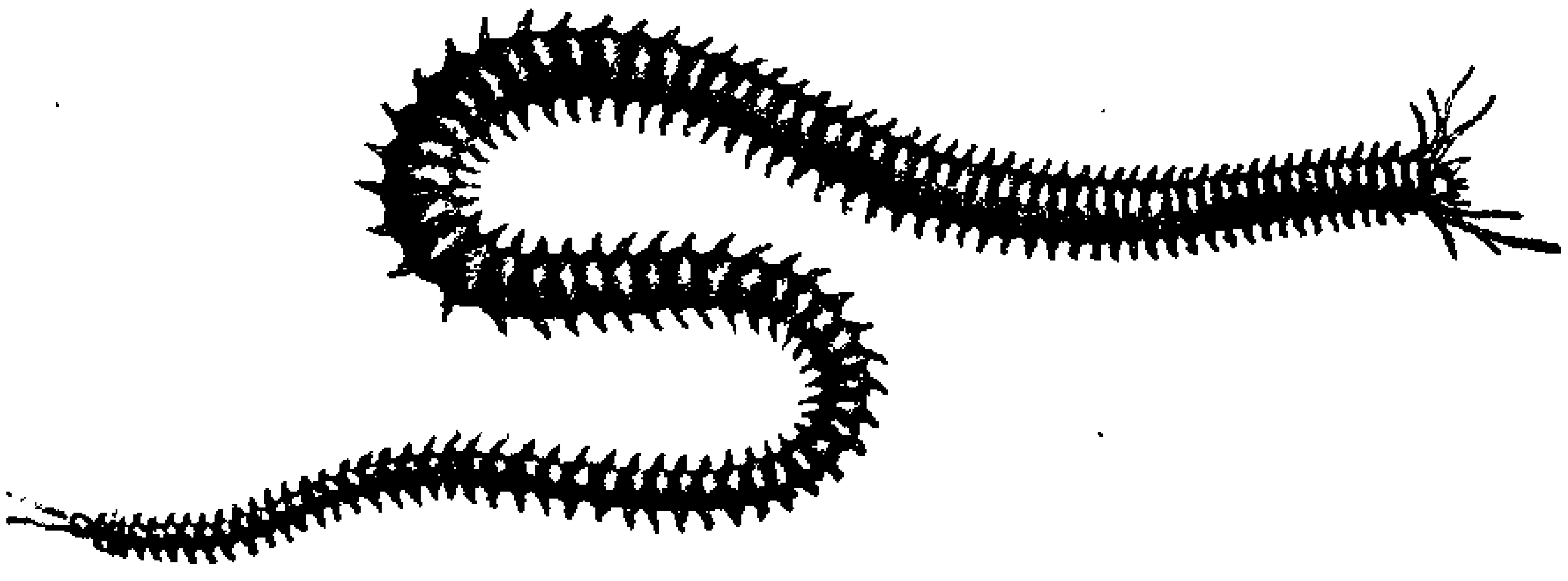


Nervous Axis of an Annelidan.

of their organisation. But a cursory examination of the *Eunice sanguinea*, a worm about two and a half feet long, and frequently

occurring on our coasts, would alone suffice to give us a very different opinion of these despised, but far from despicable creatures. The whole body is divided into segments scarce a line and a half long, and ten or twelve lines broad, and thus consists of about three hundred rings. A brain and three hundred ganglions, from which about three thousand nervous branches proceed, regulate the movements, sensations, and vegetative functions of an Eunice. Two hundred and eighty stomachs digest its food, five hundred and fifty branchiæ refresh its blood, six hundred hearts distribute this vital fluid throughout the whole body, and thirty thousand muscles obey the will of the worm, and execute its snake-like movements. What an astonishing profusion of organs! Surely there is here but little occasion to commiserate want, or to scoff at poverty!

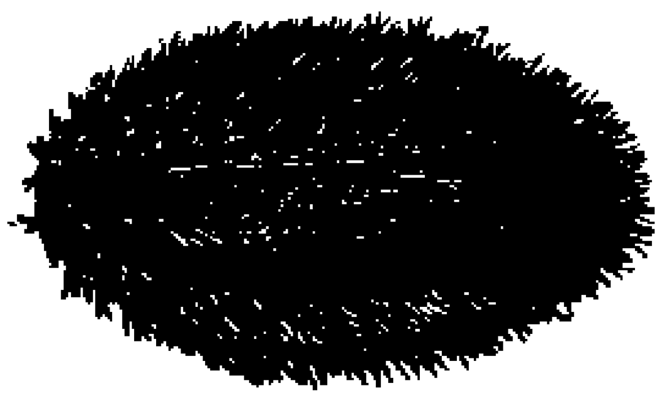
And if we look to outward appearance, we shall find that many of the marine annelides may well be reckoned among the handsomest of creatures. They display the rainbow tints of the humming-birds, and the velvet, metallic brilliancy of the most lustrous beetles. The vagrant species that glide, serpent-like, through the crevices of the submarine rocks, or half creeping, half swimming conceal themselves in the sand or mud, are pre-eminently beautiful. The delighted naturalists have consequently given them the most flattering and charming names of Greek mythology, — Nereis, Euphrosyne, Eunice, Alciopa.



Nereis.

"Talk no more of the violet as the emblem of modesty," exclaims De Quatrefages, "look rather at our annelides, that, possessed of every shining quality, hide themselves from our view, so that but few know of the secret wonders that are hidden under the tufts of algæ, or on the sandy bottom of the sea."

In most of the wandering annelides, each segment is provided with variously formed appendages, more or less developed, serving for respiration and locomotion, or for aggression and defence; while in some of the least perfect of the class, not a trace of an external organ is to be found over the whole body. The great Band-worm (*Nemertes gigas*) is one of the most remarkable examples of this low type of annelism. It is from thirty to forty feet long, about half an inch broad, flat like a ribbon, of brown or violet colour, and smooth and shining like lackered leather. Among the loose stones, or in the hollows of the rocks, where he principally lives on Anomiæ,— minute shells that attach themselves to submarine bodies,— this giant worm forms a thousand seemingly inextricable knots, which he is continually unravelling and tying. When after having devoured all the food within his reach, or from some other cause, he desires to shift his quarters, he stretches out a long dark-coloured ribbon, surmounted by a head like that of a snake, but without its wide mouth or dangerous fangs. The eye of the observer sees no contraction of the muscles, no apparent cause or instrument of locomotion; but the microscope teaches us that the Nemertes glides along by help of the minute vibratory ciliæ with which his whole body is covered. He hesitates, he tries here and there, until at last, and often at a distance of fifteen or twenty feet, he finds a stone to his taste; whereupon he slowly unrolls his length to convey himself to his new resting place, and while the entangled folds are unravelling themselves at one end, they form a new Gordian knot at the other. All the organs of this worm are uncommonly simplified; the mouth is a scarce visible circular opening, and the intestinal canal ends in a blind sack.



Aphrodita, or Sea-Mouse.

Nature has not in vain provided the more perfect annelides with the bristly feet, which have been denied to the Nemertes and the sand-worm. Almost all of them feed on a living prey, — Planarias and other minute creatures — which they enclasp and transpierce with those formidable weapons. Some, lying in wait, dart upon their victims as they heedlessly swim by, seize them with their jaws, and stifle them in their deadly embrace; others, of a more lively nature, seek them among the thickets of

corallines, millepores and algæ, and arrest them quickly ere they can vanish in the sand.

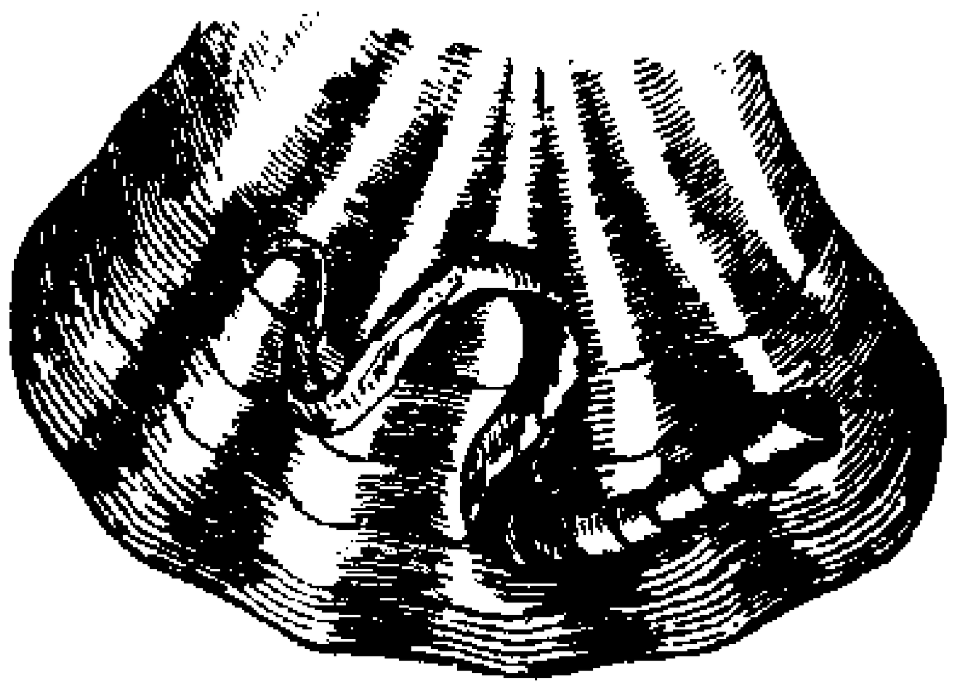
But the annelides also are liable to many persecutions. The fishes are perpetually at war with them; and when an imprudent annelide quits its hidden lurking-place, or is uncovered by the motion of the waves, it may reckon itself fortunate, indeed, if it escapes the greedy teeth of an eel or a flat-fish. It is even affirmed of the latter, as it is of the whelks, that they know perfectly well how to dig the annelides out of the sand. The sea-spiders, lobsters, and other crustacea are the more dangerous, as their hard shells render them perfectly invulnerable by the bristling weapons of the annelides.

While the greater part of these worms lead a vagrant life, others, like secluded hermits, dwell in self-constructed retreats which they never leave. Their cells, which they begin to form very soon after having left the egg, and which they afterwards continue extending and widening according to the exigencies of their growth, generally consist of a hard calcareous mass; but sometimes they are leathery or parchment-like tubes, secreted by the skin of the animal, not however forming, as in the mollusks, an integral part of the body, but remaining quite unconnected with it. Thus these tubicole annelides spend their whole life within doors, only now and then peeping out of their prison with the front part of their head.

As they lead so different a life from their roaming relations, their internal structure is very different, for where is the being whose organisation does not perfectly harmonise with his wants? Thus, we find here no bristling feet or lateral respiratory appendages; but instead of these organs, which in this case would be completely useless, we find the head surmounted by a beautiful crown of feathery tentaculæ, which equally serve for breathing and the seizing of a passing prey. Completely closed at the inferior extremity, the tube shows us at its upper end a round opening, the only window through which our hermit can peep into the world, seize his food, and refresh his blood by exposing his floating branchiæ to the vivifying influence of the water.

Do not, therefore, reproach him with vanity or curiosity, if you see him so often protrude his magnificently decorated head; but rejoice rather that this habit, to which necessity

obliges him, gives you a better opportunity for closer observation. Place only a shell or stone covered with *serpulas* or *cymospiras*, into a vessel filled with sea-water, and you will soon see how, in every tube, a small round cover is cautiously raised, which hitherto hermetically closed the entrance, and prevented you from prying into the interior. The door is open, and soon the inmate makes his appearance. You now perceive small buds, here dark violet or carmine, there blue or orange, or variously striped. See how they grow, and gradually expand their splendid boughs! They are true flowers that open before your eye, but flowers much more perfect than those which adorn your garden, as they are endowed with voluntary motion and animal life.



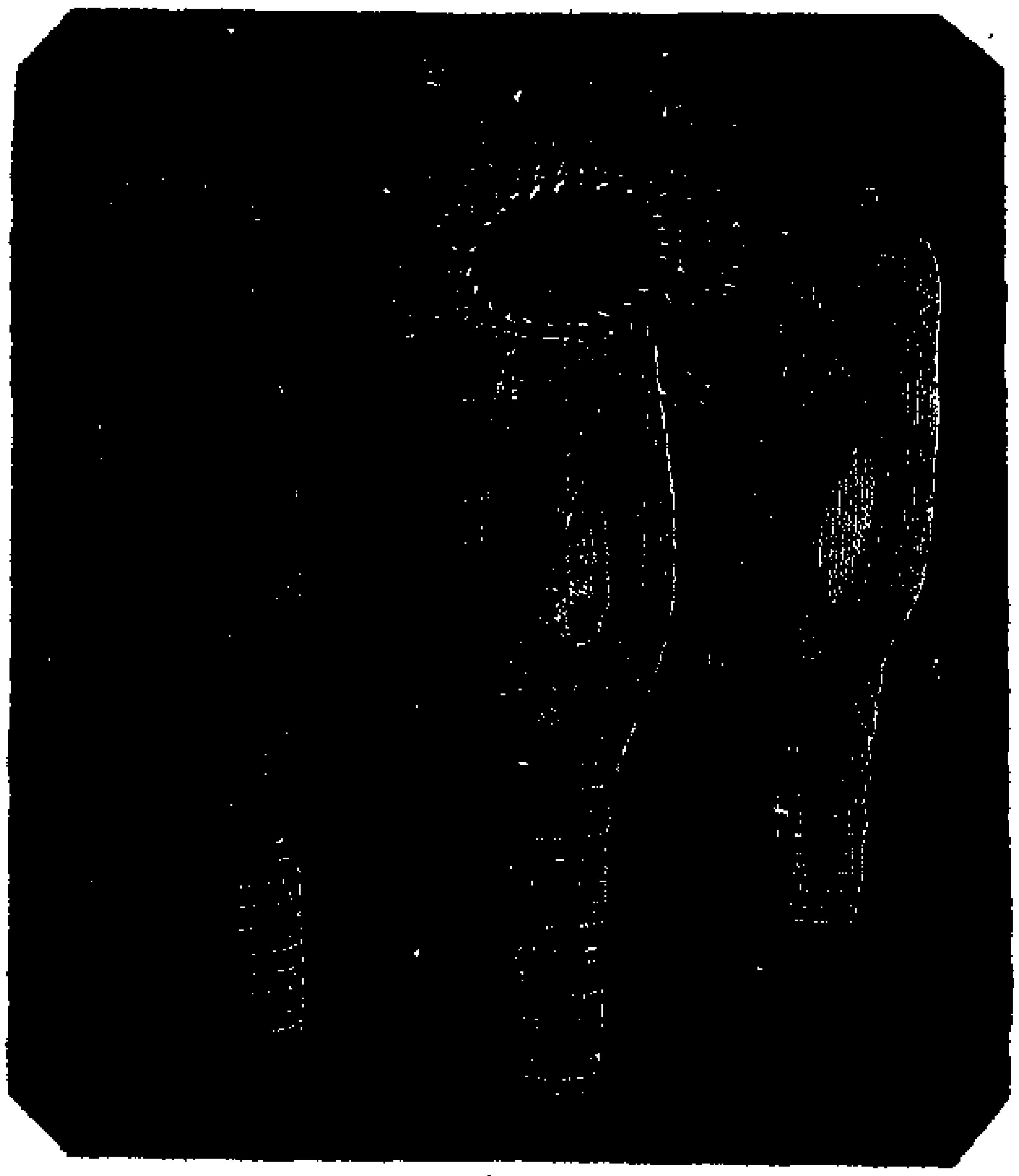
Serpula, attached to a Shell.

At the least shock, at the least vibration of the water, the splendid tufts contract, vanish with the rapidity of lightning, and hide themselves in their stony dwellings, where, under cover of the protecting lid, they bid defiance to their enemies.

Not all the tubicole annelides form grottos or houses of so complete a structure as those I have just described. Many content themselves with agglutinating sand or small shell-fragments into the form of cylindrical tubes. But even in these inferior architectural labours of the *Sabellas*, *Terebellas*, *Amphitrites*, &c., we find an astonishing regularity and art; for these elegant little tubes, which we may often pick up on the strand, where they lie mixed with the shells and algæ cast out by the flood, consist of particles of almost equal size, so artistically glued together, that the delicate walls have everywhere an equal thickness. The form is cylindrical, or funnel-shaped, the tube gradually widening from the lower to the upper end. Some of these tubicoles live like solitary hermits, others love company; for instance, the *Sabella alveolaris*, which often covers wide surfaces of rock, near low-water mark with its aggregated tubes. When the flood recedes nothing is seen but the closed orifices; but when covered with the rising waters, the sandy surface transforms itself into a beautiful picture. From

each aperture stretches forth a neck ornamented with concentric rings of golden hair, and terminating in a head embellished with a tiara of delicately feathered, rainbow-tinted tentacula. The whole looks like a garden-bed enamelled with gay flowers of elegant form and variegated colours.

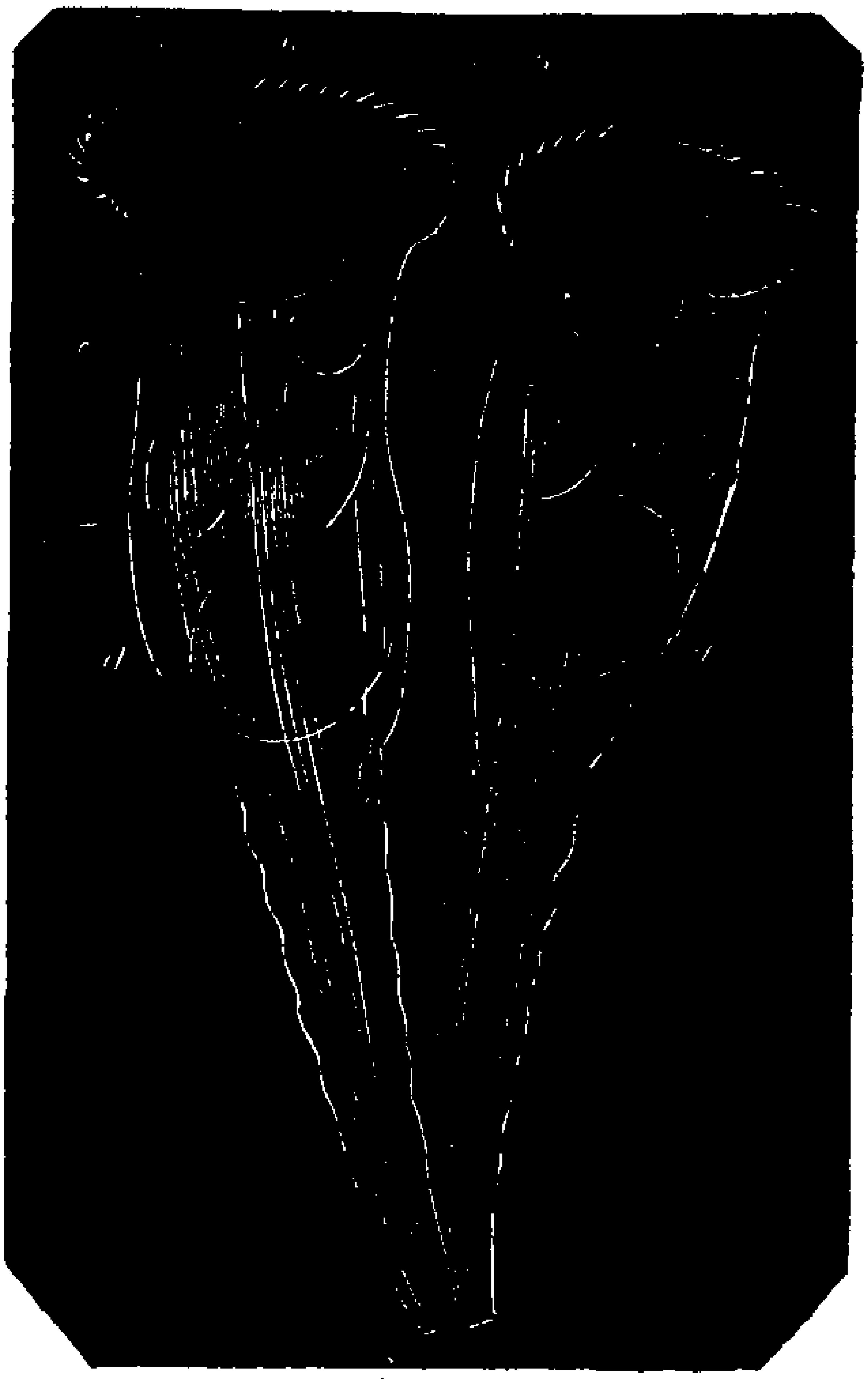
If size alone were a criterion of classification, the Rotifera would have to be ranked among the microscopic Protozoa, as they are scarcely visible to the naked eye; but a more complicated organisation separates them widely from these lowest members of the animal kingdom, and entitles them to be placed next to the worms.



Ptygura melicerta.—(A rotifer highly magnified.)
1. Partially expanded.
2. Completely expanded, the cilia in action causing currents indicated by the arrows.
3. Contracted. *a.* Contractile vesicle. *b.* Situation of the anal orifice.

They are chiefly characterised by a remarkable rotatory or ciliary apparatus, whose vibrating motions, whirling the water about in swift circles or eddies, engulf in a fatal vortex their microscopic food, or enable them to swim from place to place. Such is the crystal transparency of these curious little creatures that their internal structure can be easily recognised. The mouth is placed immediately below the rotatory apparatus, and when once an unfortunate animalcule has

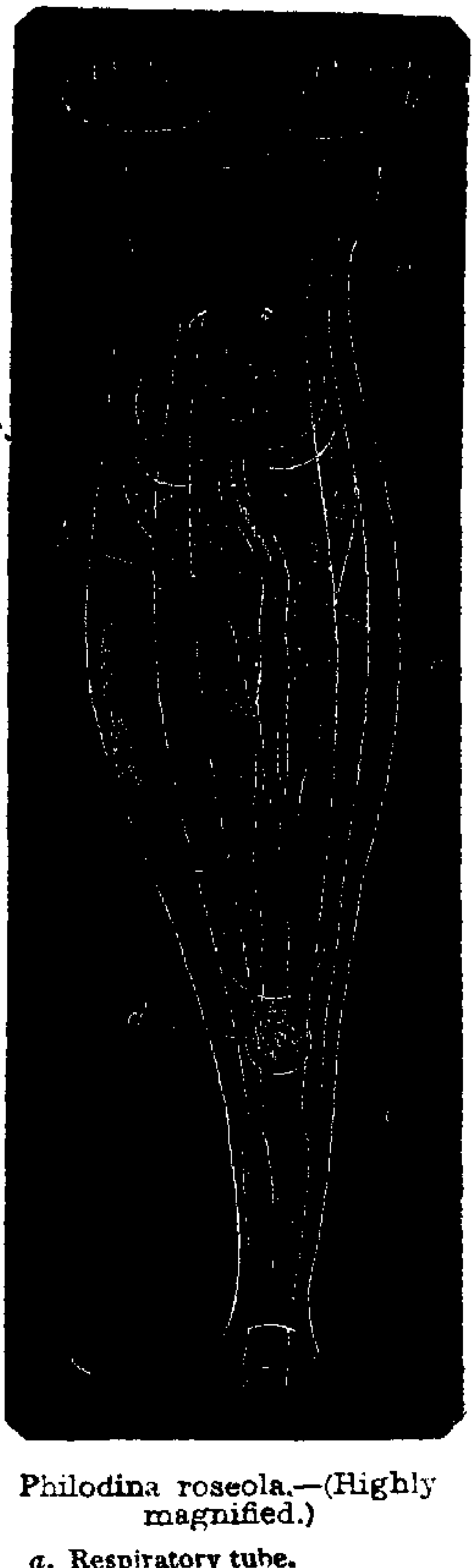
been driven into its gaping portals, it is presently crushed between a pair of formidable sharp-toothed jaws, which are perpetually in motion, whether the animal is taking food or not. After having undergone the action of this lively apparatus, the aliment passes into a tubular stomach surrounded by a cushion-like mass of cells commonly coloured with the hue of the food, and, therefore, concluded to be connected with the digestive system.



Conochilus volvox.—(Highly magnified.)
a. Jaws and teeth. *b.* Papillæ. *c.* Glands. *d.* Ovarium.

The rotifera are either naked or covered with a sheath, and many inhabit a tube formed by themselves, attached by its lower end to some water-plant, and open at the summit, from which the animal protrudes when it would exercise its active instincts, and into which it retires for repose from labour or for refuge from alarm. The majority, however, have a furcated foot, which is often capable of contraction by a set of telescopic sheathings or false joints, and by which they are enabled to secure a hold of the minute stems of water-plants. This is

their ordinary position when keeping their wheels in action for a supply of food or of water; but they have no difficulty in letting go their hold, and either creeping along by alternate contractions and extensions or swimming away in search of a new attachment. From the neck projects a telescopic spur, supposed to be an organ of respiration, and just below this are seen two minute red specks, supposed to be eyes. The first rotifer was discovered by Leeuwenhoek, in 1702; now more than 180 species are known, and new discoveries are constantly adding to their numbers. They are chiefly found in sweet water, but some are inhabitants of the sea, as, for instance, the *Synchæta baltica*, remarkable for its luminous powers. It measures about $\frac{1}{125}$ of an inch in length, and but $\frac{1}{350}$ in width, so that it is invisible to the sharpest unassisted sight: but when viewed through a microscope, it appears as a beautiful and richly organised creature, clear as glass and perfectly colourless, except that its stomach is usually distended with yellow food, and that it carries a large red eye, which glitters like a ruby.



Philodina roseola.—(Highly magnified.)

a. Respiratory tube.
b. Alimentary canal.
c. Cellular mass.
d. Terminal intestinal pouch.
e. Anal orifice.

"Its motions too," says Mr. Gosse, "are all vivacious and elegant. It shoots rapidly along or circles about in giddy dance, in company with its fellows, sometimes near the surface, at others just over the bottom of the vase in which it is kept. Occasionally the foot with the tiny toes is drawn up into the body and then suddenly thrown down, and bent up from side to side as a dog wags his tail. Sometimes the rotatory organs are brought forward and then spasmodically spring back to their ordinary position, when the little creature shoots forward with redoubled energy. In all its actions it displays vigour and precision, intelligence and will."

CHAP. XV.

MOLLUSCS.

The Molluscs in general.—The Cephalopods.—Dibranchiates and Tetrabranchiates. —Arms and Tentacles.—Suckers.—Hooked Acetabula of the Onychoteuthis.—Mandibles.—Ink Bag.—Numbers of the Cephalopods—Their Habits—Their Enemies—Their Use to Man—Their Eggs.—Enormous size of several species. —The fabulous Kraken.—The Argonaut.—The Nautili.—The Cephalopods of the Primitive Ocean.—The Gasteropods—Their Subdivisions.—Gills of the Nudibranchiates.—The Pleurobranchus plumula.—The Sea-Hare.—The Chitons. —The Patellæ.—The Haliotis or Sea-Ear.—The Carinariæ.—The Pectinibranchiates—Variety and Beauty of their Shells—Their Mode of Locomotion. —Foot of the Tornatella and Cyclostoma.—The Ianthinæ.—Sedentary Gasteropods.—The Magilus.—Proboscis of the Whelk.—Tongue of the Limpet.—Stomach of the Bulla, the Scyllæa, and the Sea-Hare.—Organs of Sense in the Gasteropods—Their Caution—Their Enemies—Their Defences—Their Use to Man.—Shell-Cameos.—The Pteropods—Their Organisation and Mode of Life. —The Butterflies of the Ocean.—The Lamellibranchiate Acephala—Their Organisation.—Siphons.—The Pholades.—Foot of the Lamellibranchiates.—The Razor-Shells.—The Byssus of the Pinnæ.—Defences of the Bivalves—Their Enemies.—The common Mussel.—Mussel Gardens.—The Oyster.—Oyster Parks.—Oyster Rearing in the Lago di Fusaro.—Formation of new Oyster Banks.—Pearl-fishing in Ceylon.—How are Pearls formed?—The Tridacna gigas.—The Teredo navalis.—The Brachiopods.—The Terebratulæ.—The Polyzoa.—The Sea-Mats.—The Escharæ.—The Lepraliæ.—Bird's Head Processes.—The Tunicata.—The Sea-Squirts.—The Chelyosoma.—The Botrylli. —The Pyrosomes.—The Salpæ.—Interesting Points in the Organisation of the Tunicata.

Simple or compound, free or sessile, peopling the high seas or lining the shores, the marine Molluscs, branching out into more than ten thousand species, extend their reign as far as the waves of ocean roll. Though distinguished from all other sea-animals by the common character of a soft unarticulated body, possessing a complicated digestive apparatus, and covered by a flexible skin or mantle, under or over which a calcareous shell is generally formed by secretion, yet their habits are as various as their forms. Some dart rapidly through the waters, others creep slowly along, or are firmly bound to the rock; in some

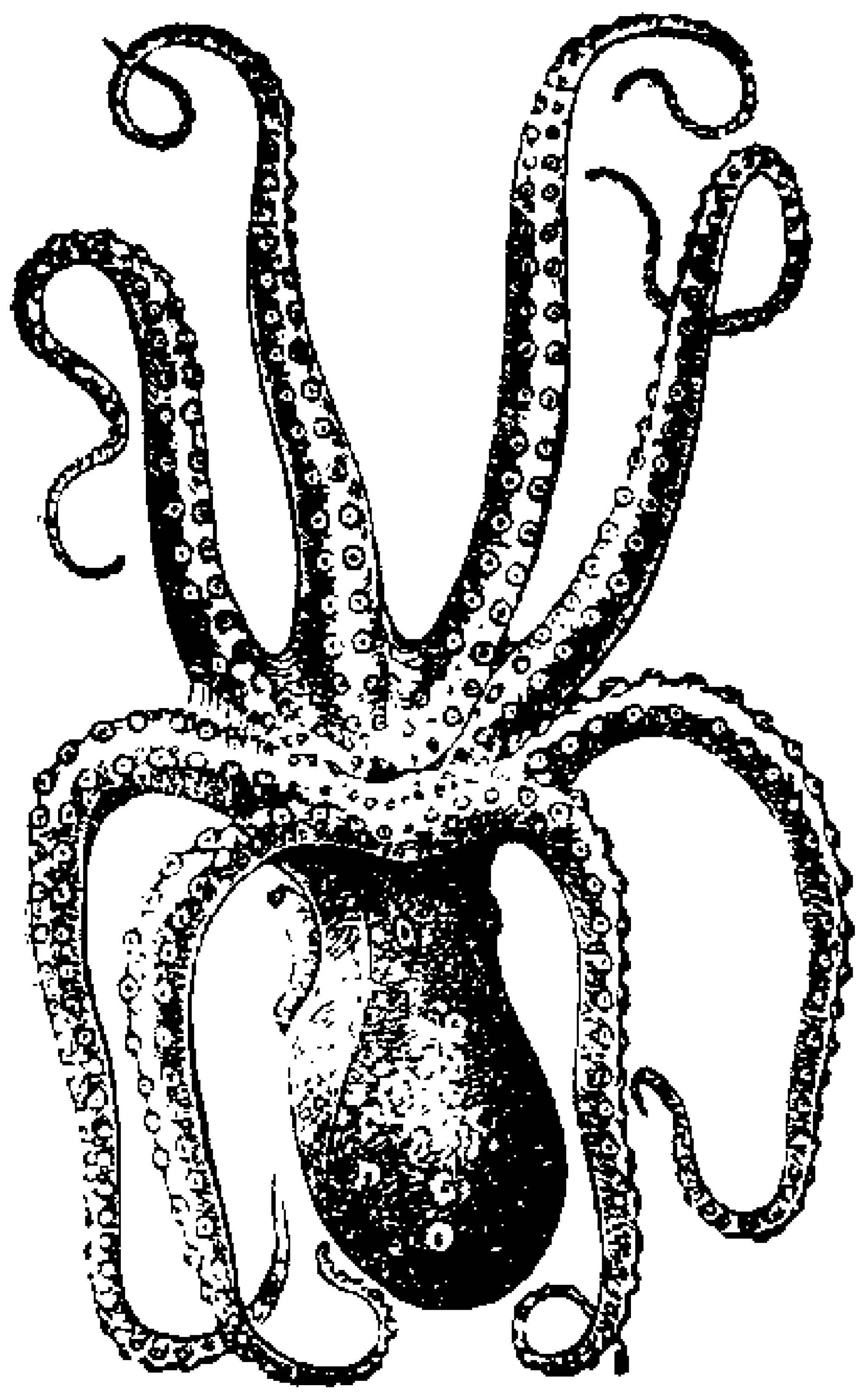
the senses are as highly developed as in the fishes, in others they are confined to the narrow perceptions of the polyp. Many are individually so small as to escape the naked eye, others of a size so formidable as to entitle them to rank among the giants of the sea; some are perfectly harmless and unarmed, others fully equipped for active warfare. It is evident that creatures so variously gifted, and consequently so widely dissimilar in structure, cannot possibly be grouped together in one description, and that each of the four orders, Cephalopoda, Gasteropoda, Pteropoda, and Acephala (Lamellibranchiates, Brachiopods, Polyzoa, and Tunicata), into which they have been subdivided, must be separately brought before the reader, in order to give him a clear and faithful picture of their organisation and mode of life.

The Cephalopods are the most perfect specimens of the molluscan type, as the decapods are the first among the crustaceans. These remarkable creatures consist of two distinct parts: the trunk or body, which, in form of a sack, open to the front, encloses the branchiæ and digestive organs, and the well-developed head, provided with a pair of sharp-sighted eyes, and crowned with a number of fleshy processes, arms or feet, which encircle and more or less conceal the mouth. It is to this formation that the cephalopod owes its scientific name, for as the feet grow from the circumference of the mouth, it literally creeps upon its head.

All the cephalopods are marine animals, and breathe through branchiæ or gills. These are concealed under the mantle, in a cave or hollow, which alternately expands and contracts, and communicates by two openings with the outer world. The one in form of a slit serves to receive the water; the other, which is tubular, is used for its expulsion.

According to the different number of their gills, the cephalopods are divided into two groups. The first, to which the poulp and common cuttle-fish belong, and which comprises by far the majority of living species, has only two sets of gills; while the second, which, in the present epoch, is only represented by a few species of Nautilus, has four, two on each side, according to the number of their arms or feet—for these remarkable organs serve equally well for prehension or locomotion. The first group is again subdivided into two

orders, Octopods and Decapods, the former having only eight sessile feet, while the latter possess an additional pair of elongated tentacles, which serve to seize a prey that may be beyond the reach of the ordinary feet, and also to act as anchors to moor them in safety during the agitations of a stormy sea.



Poulp (Octopus).

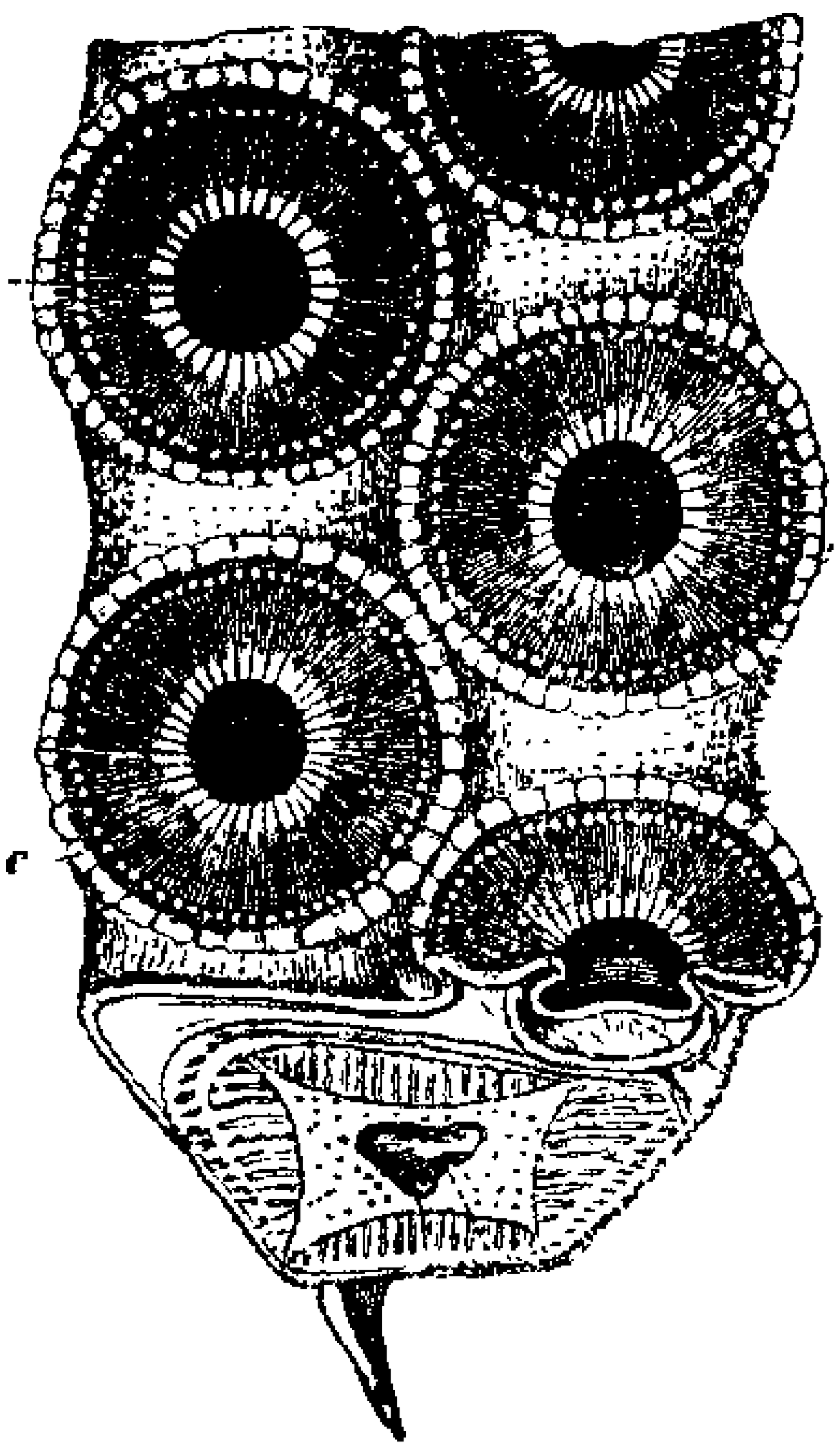
Both the arms and tentacles are furnished with suckers disposed along the whole extent of the inner surface of the former, but generally confined to the widened extremities of the latter, where they are closely aggregated on the inner aspect.

In all the octopods the suckers are soft and unarmed. Every sucker is composed of a circular adhesive disk, which has a thick fleshy circumference and bundles of muscular fibres radiating towards the circular orifice of an inner cavity. This widens as it descends, and contains a cone of soft substance, rising from the bottom of the cavity, like the piston of a syringe. When the sucker is applied to a surface for the purpose of adhesion, the piston, having previously been raised so as to fill the cavity, is retracted, and a vacuum produced, which may be still further increased by the retraction of the plicated central portion of the disk. So admirably are these air-pumps constructed, and so tenacious is their grasp, that, when they have once seized or fixed upon a prey, it cannot possibly disengage itself from their murderous embrace.

Calamary.

In many of the decapods, who, generally seeking their prey in

the deeper waters, have to contend with the agile, slippery, and mucus-clad fishes, more powerful organs of prehension have been superadded to the suckers. Thus, in the Calamary the base of the piston is enclosed by a horny hoop, the margin of which is developed into a series of sharp-pointed curved teeth; and in the still more formidable Onychoteuthis each hoop is produced into the form of a long, curved, and sharp-pointed claw (f), which the predacious mollusc presses firmly into the flesh of its struggling victim, and then withdraws by muscular contraction.



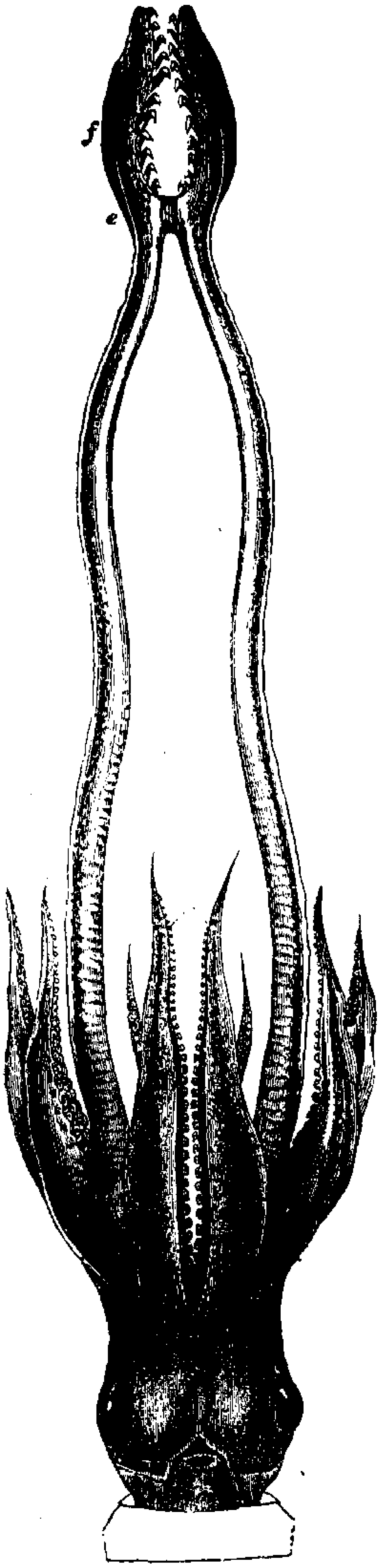
Section of an arm and suckers of a Poulp.

e. Soft and tumid margin of the disk.
g. Circular aperture.

Besides the hooked acetabula, a cluster of small simple unarmed suckers may be observed at the base of the expanded part. These add greatly to the animal's prehensile powers, for when they are applied to one another (e), the tentacles are firmly locked together at that point, and the united strength of both the elongated peduncles can be applied to drag towards the mouth any resisting object which has been grappled by the terminal hooks. There is no mechanical contrivance which surpasses the admirable structure of this natural forceps.

The size of the arms and the arrangement of the suckers differ considerably in the various species. In the octopods or poulps, which generally lead a more sedentary creeping life, and, hidden in the crevices of rocks, await the passing prey, the arms, in accordance with their wants, are with rare exceptions longer, more muscular, and stronger, than in the actively swimming decapods, where the two elongated tentacles or peduncles are the chief organs of prehension. In some species we find the arms distinct—in others they are united by a membrane. Some have a double row of suckers on each arm, others four rows, others again but one. So wonderful are the variations which nature, that consummate artist, plays upon a single theme—so inexhaustible are the modifications she introduces into the

formation of numerous species, all constructed upon the same fundamental plan, and all equally perfect in their kind.



Arms and Tentacles of an Onychoteuthis.

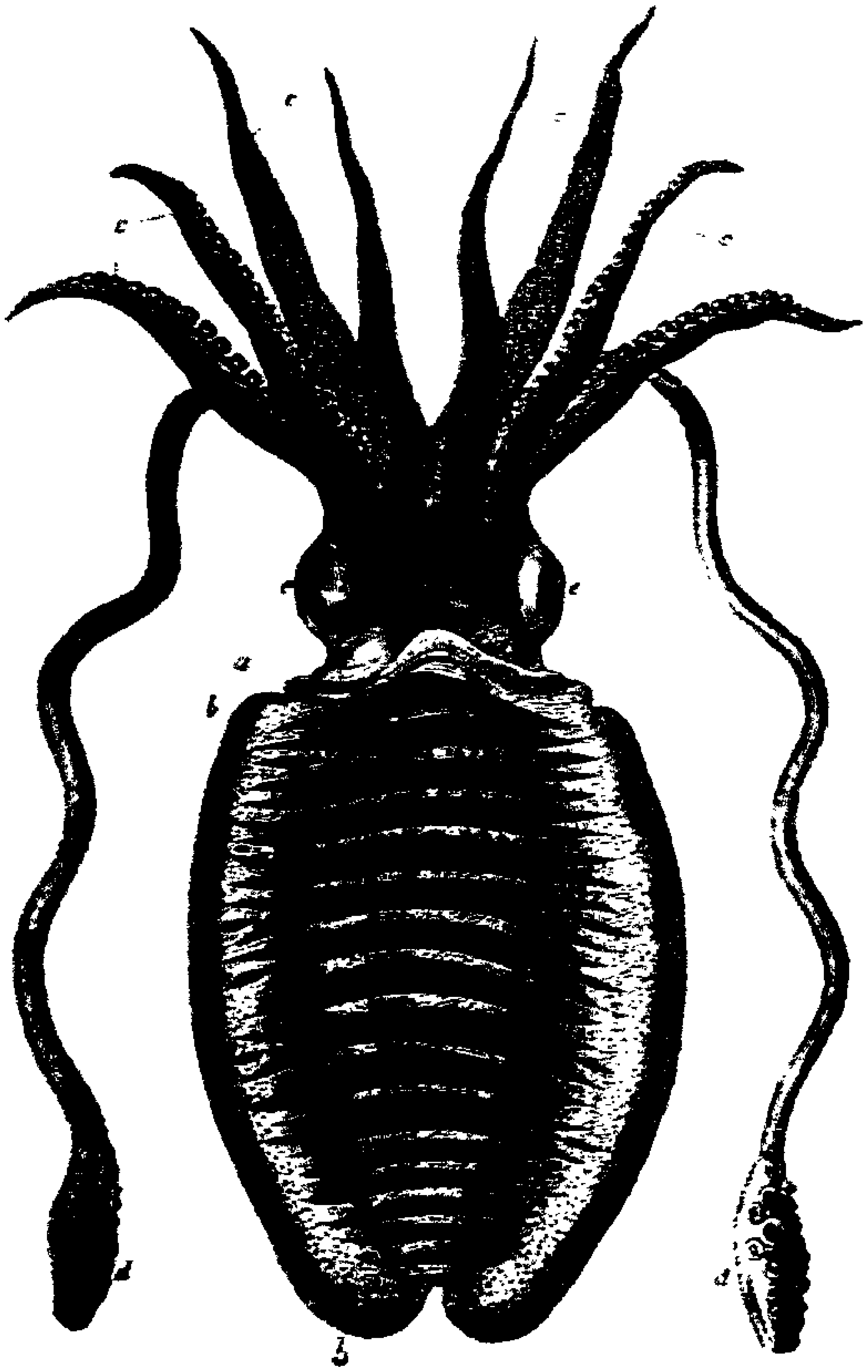
e. Parts joined together by the mutual apposition of the armed suckers.
f. Terminal expanded portions bearing the hooks.

Thus well provided with the means for seizing and overcoming the struggles of a living prey, the Cephalopods likewise possess adequate weapons for completing its destruction; for their mouth is most formidably armed with two horny or calcareous jaws, shaped like the mandibles of a parrot, playing vertically on each other, and enclosing a large fleshy tongue bristling with recurved horny spines. Hard, indeed, must be the crab which can resist this terrible beak; and when the cuttle-fish has once fixed on the back of a fish, though much larger and stronger than himself, it is in vain for the tortured victim to fly through the water: he carries his enemy with him till he sinks exhausted under his murderous fangs.

Besides their arms, by help of which the Cephalopods either swim or creep, the forcible expulsion of the water through the respiratory tube or infundibulum serves them as a means of locomotion in a backward direction. By those which have an elongated body and comparatively strong muscles, this movement is performed with such violence that they shoot like arrows through the water, or even like the flying-fish perform a long curve through the air.

Thus Sir James Ross tells us, that once a number of cuttle-fish not only fell upon the deck of his ship, which rose fifteen or sixteen feet above the water, and where more

than fifty were gathered, but even bolted right over the entire breadth of the vessel, like a sportsman over a five-barred gate. Finally, the fin-like expansion of their mantle renders the nimble decapods good service in swimming. In the Sepias this



b. Finny membrane running along the sides of the body. c. Arms with four rows of suckers. d. Elongated retractile tentacles. e. Eyes.

finny membrane runs along the sides of the body, while in the Calamary it forms a kind of terminal paddle.

It might be supposed that the dibranchiate cephalopods, by their swiftness, their arms, and their powerful jaws, were sufficiently provided with means of attack or defence; but it must

be remembered that their body is soft and naked, and that, though well armed in front, they may readily be attacked in the rear. To afford them the additional protection they required, nature, ever ready to minister to the real wants of her children, has furnished them with an internal bag communicating with the respiratory tube, and secreting a large quantity of an inky fluid, which they can squirt out with force in the face of their foe, and which, mixing readily with the water, envelops them in an opaque cloud, and thus screens them from pursuit. But this inky fluid, thus useful to its owner, is often the cause of his destruction by man, who applies it to his own purpose, for the Italian pigment, called sepia, so invaluable to painters in water-colours, is prepared from the inspissated contents of the ink bag of a cuttle-fish. Such is the durability of this colour that even the inky fluid of fossil species has been found to retain its chromatic property. We are told that grains of wheat buried with Egyptian mummies three thousand years ago have germinated; but it is surely still more astonishing that an animal secretion, the origin of which is lost in the dark abyss of countless ages, should remain so long unaltered.

The cephalopods are scattered in vast numbers over the whole ocean, from the ice-bound shores of Boothia Felix to the open main; they seem, however, to be most abundant in temperate latitudes. Some, like the common poulp, constantly frequent the coasts, creeping among the rocks and stones at the bottom; others, like the Cirroteuthis and Ommastrephes, roam about the high seas at a vast distance from the land.

They are generally nocturnal or vespertine in their habits; they abound towards evening and at night on the surface of the seas, but sink to a greater depth, or retire into the crevices of the rocks, as soon as the sun rises above the horizon. Some are of a recluse disposition, and lead a solitary life in the anfractuosities of the littoral zone; others, of a more social temper, wander in large troops along the shores, or over the vast plains of ocean.

Possessing the organs of sense, and the means of locomotion in a high degree of development, the cephalopods may naturally be expected to be far more active and intelligent than the inferior orders of the molluscs. On moonlight nights, among

the islands of the Indian Archipelago, Mr. Adams frequently observed the Sepiæ and Octopi in full predatory activity, and had considerable difficulty and trouble in securing them, so great was their restless vivacity, and so vigorous their endeavours to escape. "They dart from side to side of the pools," says the naturalist in his entertaining and instructive account of his journey to those distant gems of the tropical sea, "or fix themselves so tenaciously to the surface of the stones by means of their suckers that it requires great force and strength to detach them. Even when removed and thrown upon the sand, they progress rapidly, in a sidelong shuffling manner, throwing about their long arms, ejecting their ink-like fluid in sudden violent jets, and staring about with their big shining eyes (which at night appear luminous, like a cat's) in a very grotesque and hideous manner."

At the Cape de Verd islands, Mr. C. Darwin was also much amused by the various arts to escape detection used by a cuttle-fish, which seemed fully aware that he was watching it. Remaining for a time motionless, it would then stealthily advance an inch or two, like a cat after a mouse, and thus proceeded, till, having gained a deeper part, it darted away, leaving a dusky train of ink, to hide the hole into which it had crawled.

All the cephalopods are extremely voracious; they destroy on shallow banks the hopes of the fishermen, devour along the coasts and on the high seas countless myriads of young fish and naked molluscs, and kill, like the tiger, for the mere love of carnage. Thus they would become dangerous to the equilibrium of the seas if nature, to counterbalance their destructive habits, had not provided a great number of enemies for the thinning of their ranks.

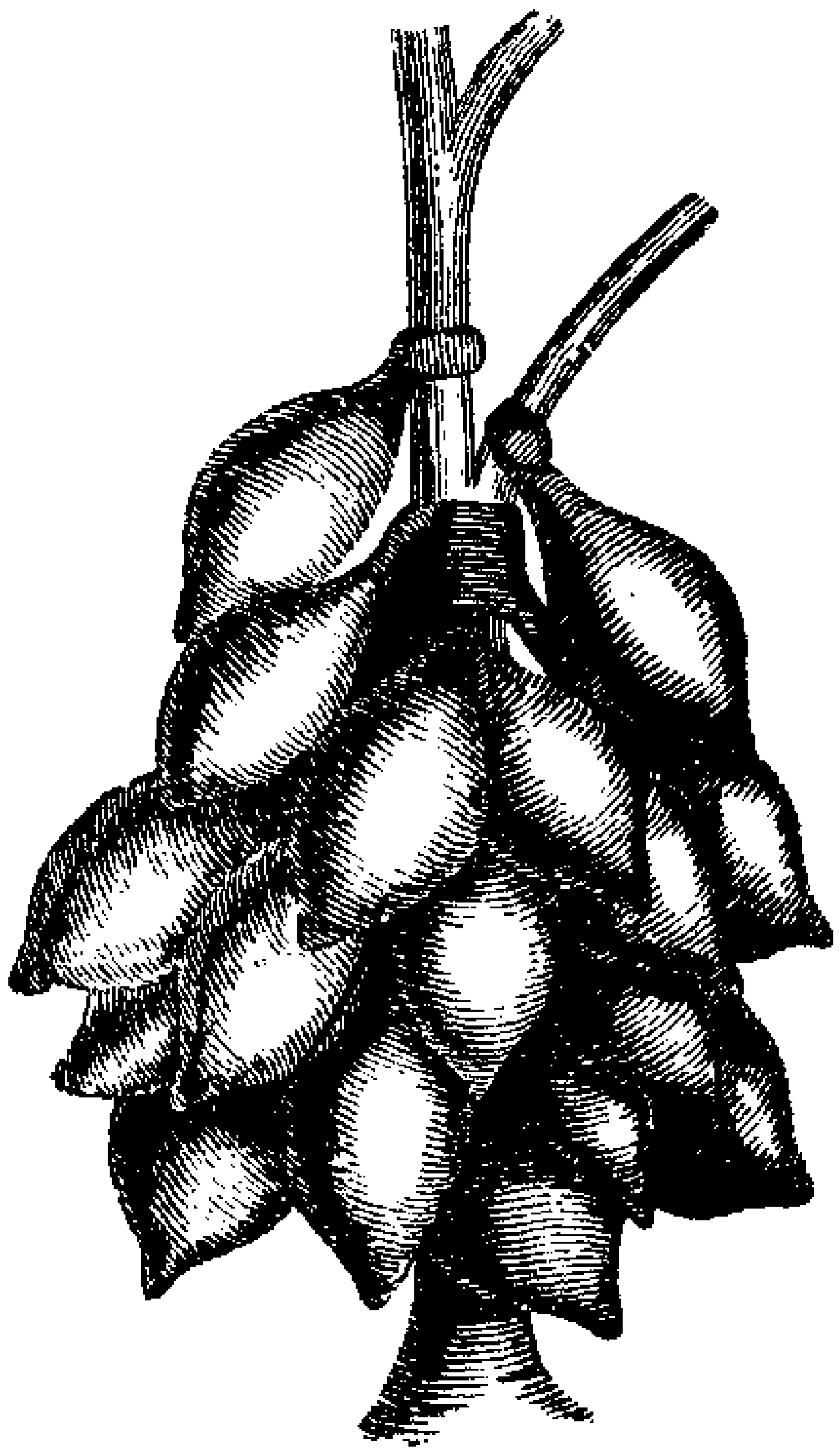
They form the almost exclusive food of the sperm-whales, and the albatross and the petrels love to skim them from the surface of the ocean. Tunnies and bonitos devour them in vast numbers, the cod consumes whole shoals of squids, and man, as I have already mentioned, catches many millions to serve him as a bait for this valuable fish.

At Teneriffe, in the Brazils, in Peru and Chili, in India and China, various species of cephalopods are used as food. Along the eastern shores of the Mediterranean, the common sepia

constitutes now, as in ancient times, a valuable part of the food of the poor. "One of the most striking spectacles," says Edward Forbes, "is to see at night on the shores of the Ægean the numerous torches glancing along the shores, and reflected by the still and clear sea, borne by poor fishermen, paddling as silently as possible over the rocky shallows in search of the cuttle-fish, which, when seen lying beneath the water in wait for his prey, they dexterously spear, ere the creature has time to dart with the rapidity of an arrow from the weapon about to transfix his soft but firm body."

Animals exposed to the attacks of so many enemies must necessarily multiply in an analogous ratio. Their numerous eggs are generally brought forth in the spring. In the species inhabiting the high seas, they float freely on the surface, carried along by the currents and winds, and form large gelatinous bunches or cylindrical rolls, sometimes as large as a man's leg.

The eggs of the littoral cephalopods appear in the form of dark-coloured, roundish or spindle-shaped bodies, of the size and colour of grapes, and hanging together in clusters. They are soft to the touch, with a tough skin, resembling india-rubber; one end is attenuated into a sort of point or nipple, and the other prolonged into a pedicle, which coils round seaweed or other floating objects, and serves to fix the berry-like bag in its place. At an early stage these "sea-grapes," as they are called by the fishermen, contain a white yolk enclosed in a clear albumen, and nearer maturity the young cuttle-fish may be found within in various stages of formation, until finally, hatched by the heat of the sun, it emerges from the husk perfectly formed, and launches forth into the water.



Ova of the Cuttle-fish.

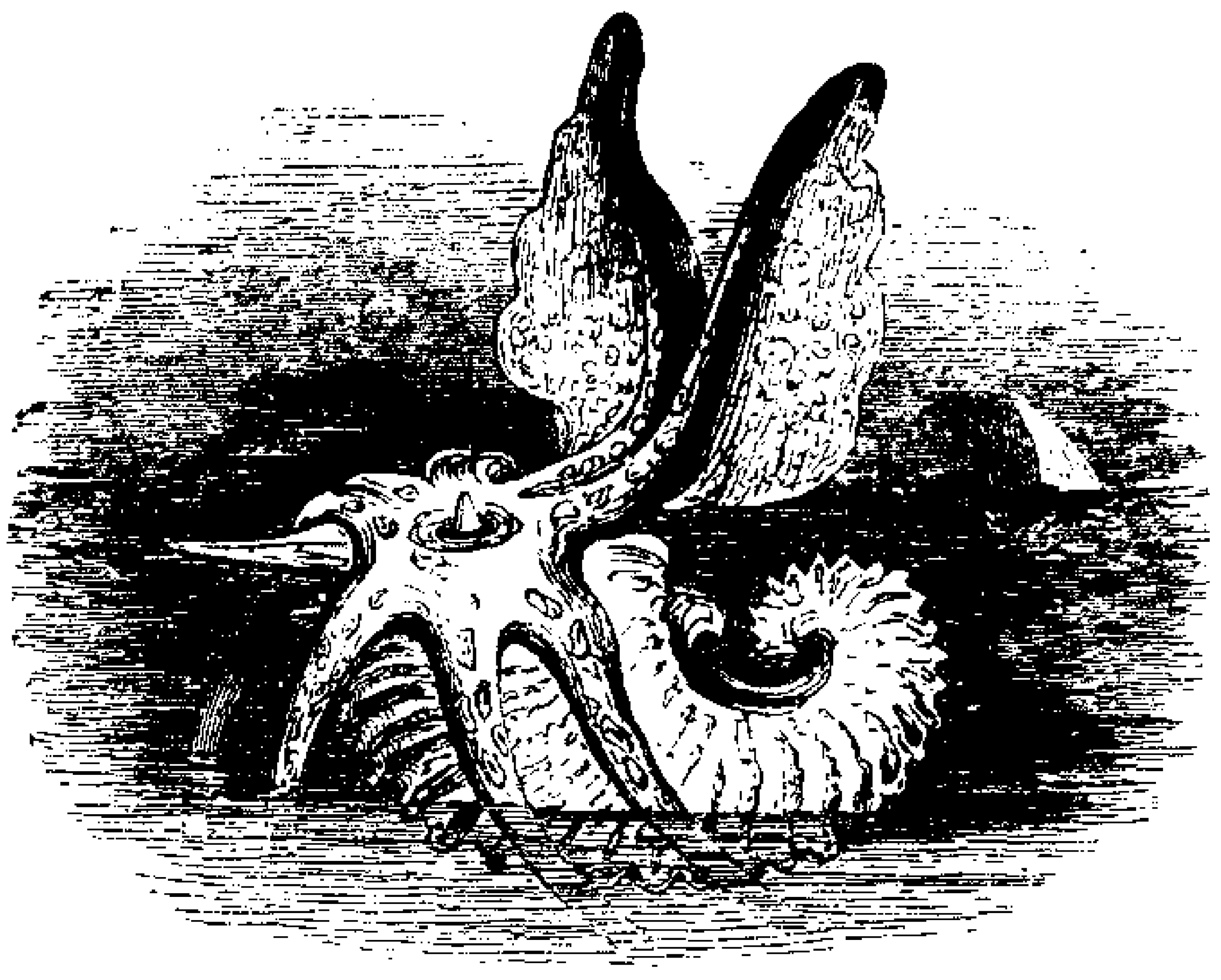
Some species of cephalopods are only about the size of a finger, while others attain an astonishing size. Banks and Solander, in

Cook's first voyage, found the dead carcass of a gigantic cuttle-fish floating between Cape Horn and the Polynesian islands. It was surrounded by aquatic birds, which were feeding on its remains. From the parts of this specimen, which are still preserved in the Hunterian collection, and which have always strongly excited the attention of naturalists, it must have measured at least six feet from the end of the tail to the end of the tentacles.

Near Van Diemen's Land, Péron saw a sepia about as big as a tun rolling about in the waters. Its enormous arms had the appearance of frightful snakes. Each of these organs was at least seven feet long, and measured seven or eight inches round the base. These well authenticated proportions are truly formidable, and fully justify the dread and abhorrence which the Polynesian divers entertain of those snake-armed monsters of the deep; but not satisfied with reality, some writers have magnified the size of the cephalopods to fabulous dimensions. Thus Pernetti mentions a colossal cuttle-fish, which, climbing up the rigging, overturned a three-masted ship; and Pliny notices a similar giant, with arms thirty feet long and a corresponding girth. But all this is nothing to the Norwegian kraken, a mass of a quarter of a mile in diameter, and a back covered with a thicket of sea-weeds. When it comes to the surface, which seems to be but rarely the case, it raises its arms mast-high into the air, and, having enjoyed for a time the lovely daylight, sinks slowly back again into abysmal darkness. Fishermen are said to have landed on a kraken, and to have kindled a fire upon the supposed island for the purpose of cooking their dinner. But even a kraken, thick-skinned as he may be, does not like his back to be converted into a hearth, and thus it happened that the treacherous ground gave way under the mistaken mariners, and overwhelmed them in the waters. Strange that the oriental tale of Sinbad the sailor should thus be re-echoed in the wild legends of the north.

All the dibranchiate cephalopods are destitute of an outward shell, with the sole exception of the Spirula, a small species chiefly found in the South Sea, and of the far more renowned Argonaut, which poets, ancient and modern, have celebrated as the model from which man took the first idea of navigation.

Its two sail-like arms expanding in the air, and the six others rowing in the water, the keel of its elegant shell is pictured as dividing the surface of the tranquil sea. But as soon as the wind rises, or the least danger appears, the cautious argonaut takes in his sails, draws back his oars, creeps into his shell,

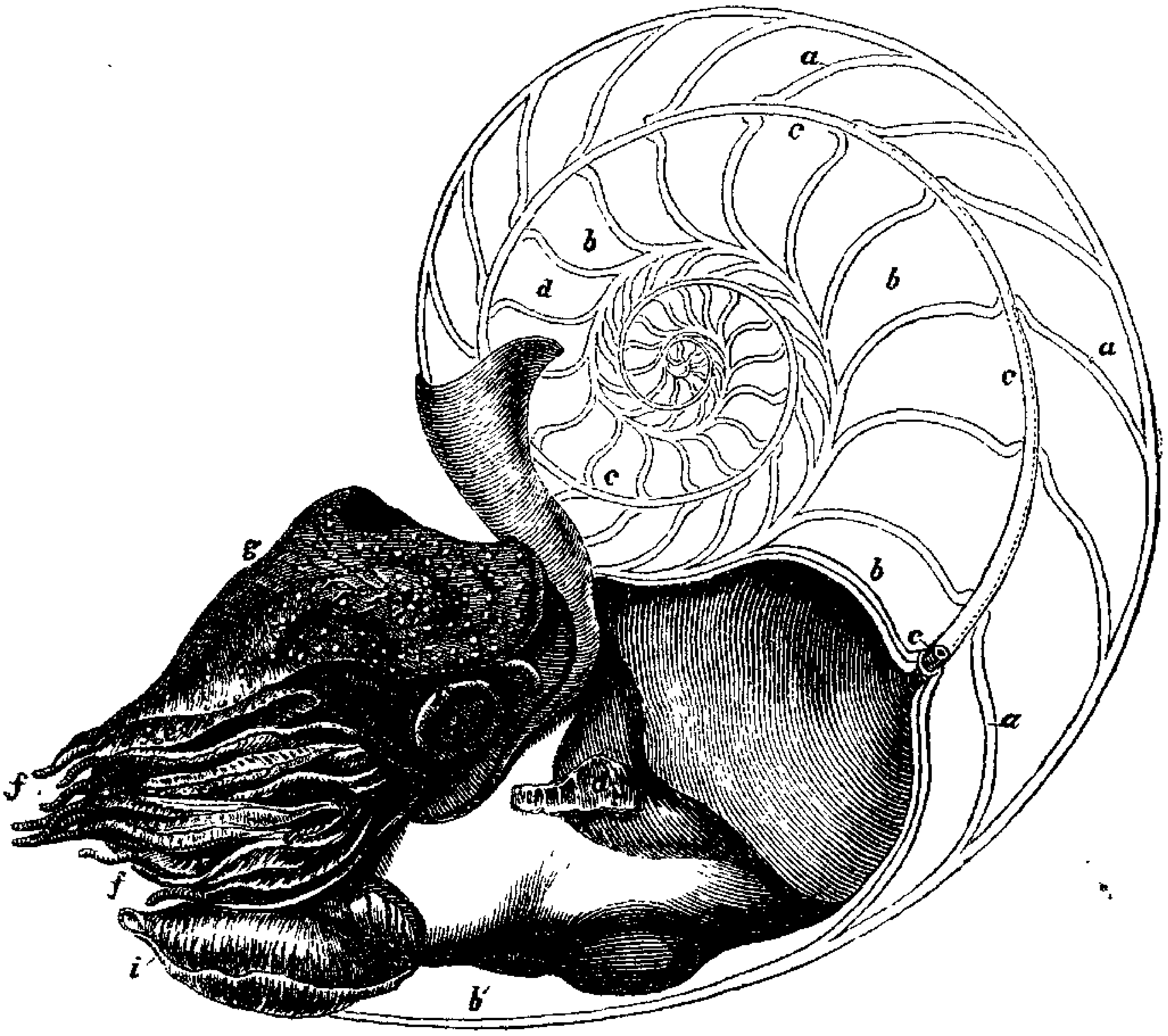

Argonaut.

and sinks instantly into a securer depth. Unfortunately there is not a word of truth in this pleasing tale. Like the common octopus, the argonaut generally creeps about at the bottom of the sea, or when he swims, he places his sails close to his shell, stretches his oars right out before him, and shoots backwards like most of his class by expelling the water from his respiratory tube.

As he sits loosely in his shell, he was supposed by some naturalists to be a parasite enjoying the house of the unknown murdered owner; but this is perfectly erroneous, as the young in the egg already show the rudiments of the future shell, and the full-grown animal repairs by reproduction any injury that may have happened to it.

The tetrabranchiate cephalopods, or Nautili, are very differently constructed from their dibranchiate relations. Here, instead of mighty muscular arms, furnished with suckers or raptorial claws, we find a number of small, sheathed, and retractile tentacles (*f*), surrounding the mouth in successive series, and amounting to little short of a hundred. The head is further provided with a large muscular disk (*g*), which, besides acting as a defence to the opening of the shell, serves also in all probability as an organ for creeping along the ground, like the foot in the Gasteropods. The mandibles are strengthened by a dense calcareous substance fit to break up the defensive armour of the crustacean or shell-fish on which the animal feeds. There is no ink-bag, no organ of hearing, and the eyes (*h*) are pedunculated, and of a

more simple structure. The handsome pearl-mother and spirally wound shell is divided by transverse partitions (*a*), perforated in the centre, into numerous chambers (*b*). The animal takes up its abode in the foremost and largest (*b′*), but sends a communicating tube or siphon (*c*) through all the holes of the partitions to the very extremity of the spirally wound shell. Though the empty conch was frequently found swimming on the waters of the Indian Ocean, or cast ashore on the Moluccas or New Guinea, yet it was only in 1829 that the animal was known with



Pearly Nautilus.

any certainty, one having been caught alive by Mr. George Bennett, near the New Hebrides, which, preserved in spirits, is now in the museum of the College of Surgeons. Since then three different species have been found to abound in the waters of the above-named archipelago, of New Caledonia, and of the Feejee and Solomon Islands, where they principally sojourn among the coral reefs at depths of from three to six fathoms. They usually remain at the bottom of the water, where they creep along rather quickly, supporting themselves upon their

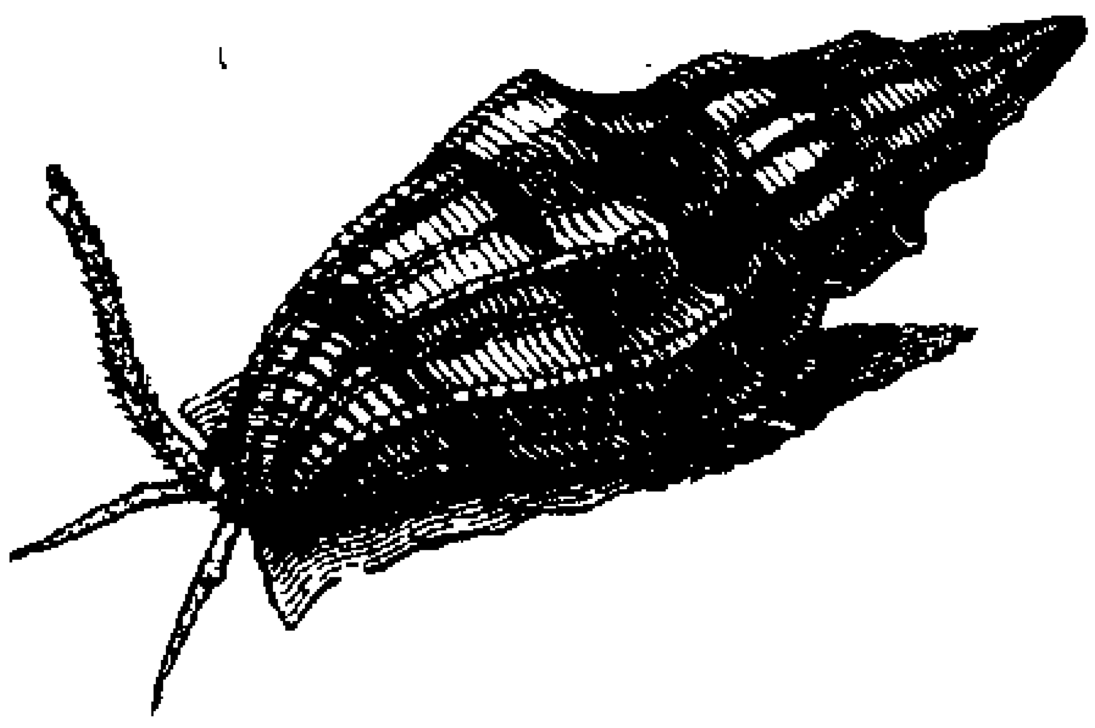
tentacula, with their head downwards and the shell raised above. After stormy weather, as it becomes more calm, they may be seen in great numbers floating upon the surface of the sea with the head protruded, and the tentacula resting upon the water, the shell at the same time being undermost; they remain, however, but a short time sailing in this manner, as they can easily return to their situation at the bottom of the sea, by merely drawing in their tentacles and upsetting the shell. They are caught in baskets by the natives, who eat them roasted as a great delicacy.

What renders these animals peculiarly interesting is the circumstance that they are the only living representatives of a class which once filled in countless numbers the bosom of the primeval ocean, and whose fossil remains (Orthoceratites, Ammonites) furnish the naturalist with a series of historical documents, attesting the unmeasured age of our planet. What are the ruins, thirty or forty centuries old, that speak of the vanished glories of extinguished empires to these wonderful medals of creation that lead our thoughts through the dim vista of unnumbered centuries to the fathomless abyss of the past.

In point of development of organisation the Gasteropods or snails rank immediately after the Cephalopods. They also have a head plainly distinguishable from the rest of the body, and to which two brilliant black eyes give an animated expression. But their nervous system is far less developed, and while the lively cephalopod is able to swim about, and rapidly to seize a distant prey, almost all the gasteropods creep slowly along upon a flat disk or foot situated below the digestive organs, a formation to which they owe their name of gasteropods or stomach-footers.

The marine snails are divided into several groups according to the different position and arrangement of their gills. In some species these organs form naked or free-swimming tufts on the back (Nudibranchiata) but generally they are variously disposed either in special cavities or under the folds of the mantle. Thus in the Inferobranchiata they are arranged

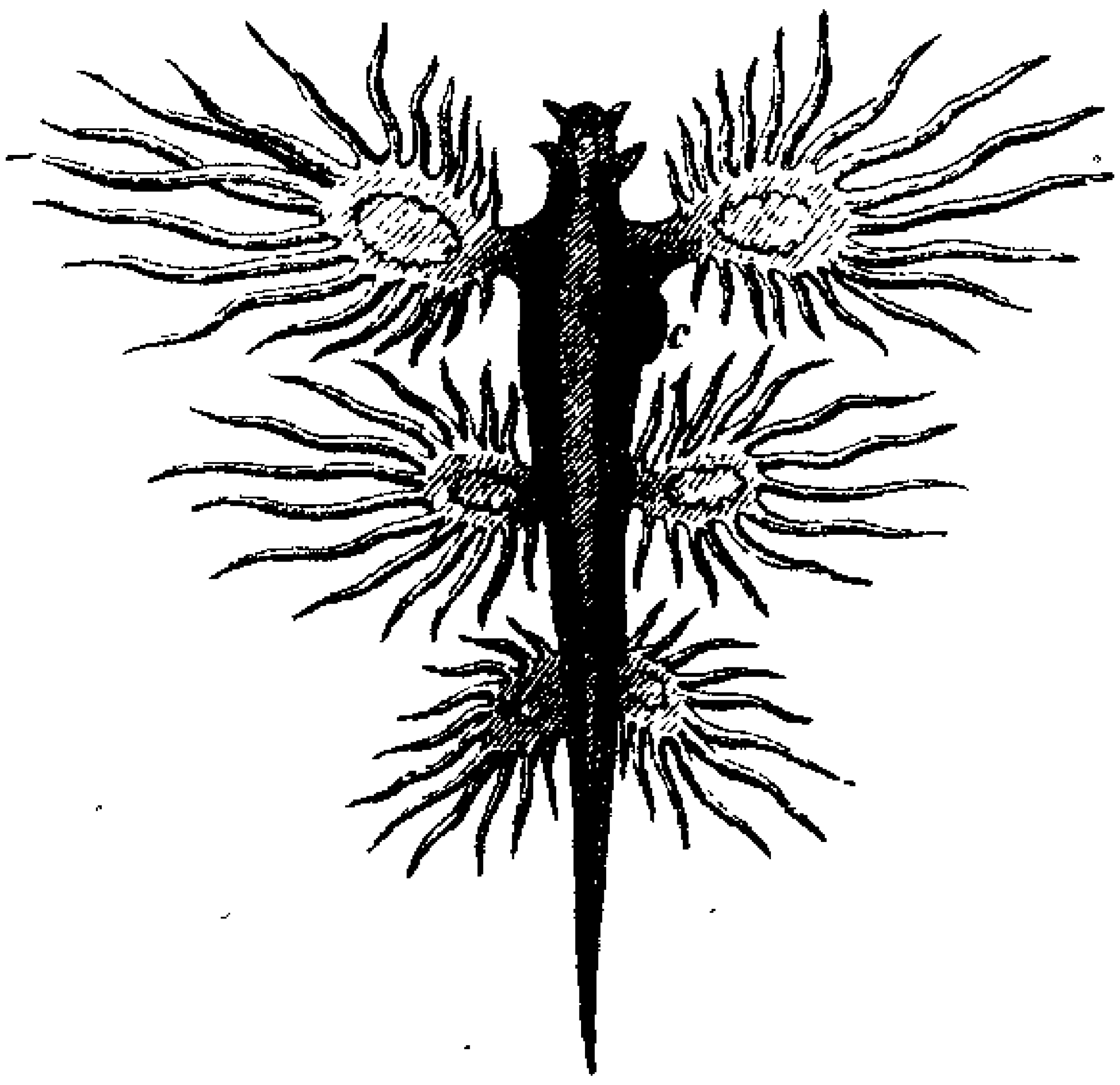
under its inferior border on both sides of the body, or upon one side only, while in the Tectibranchiata they are placed, as in the Nudibranchiata, upon the dorsal aspect of the body, but are protected by a fold of the skin. In the Cyclobranchiata they form a fringe round the margin of the body, between the edge of the mantle and the foot, and in the Scutibranchiata and Pectinibranchiata they are pectinated, or



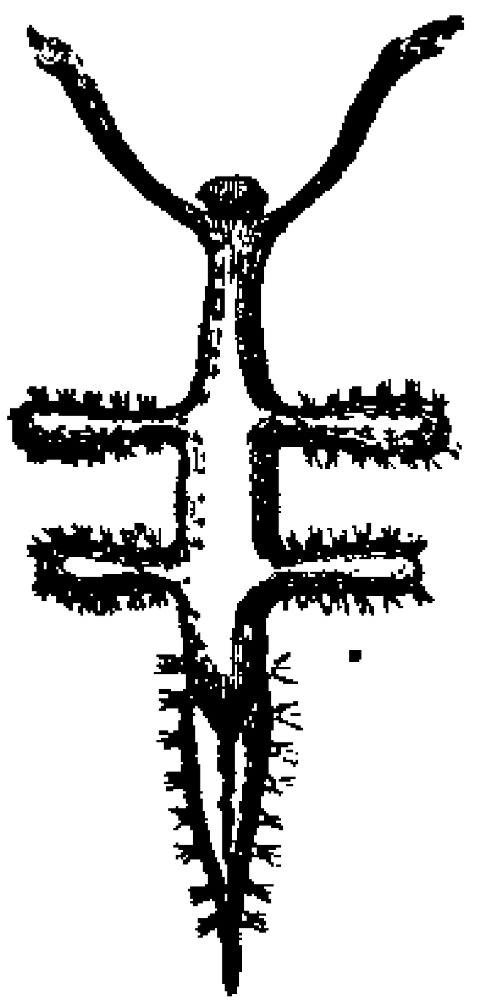
Tiara.

shaped like the teeth of a comb, and placed in a large hollow chamber, which opens externally at the side of the body or above the head.

Nothing can be more elegant or various than the form and arrangement of the gills in most of the nudibranchiate gastero-



Glaucus.

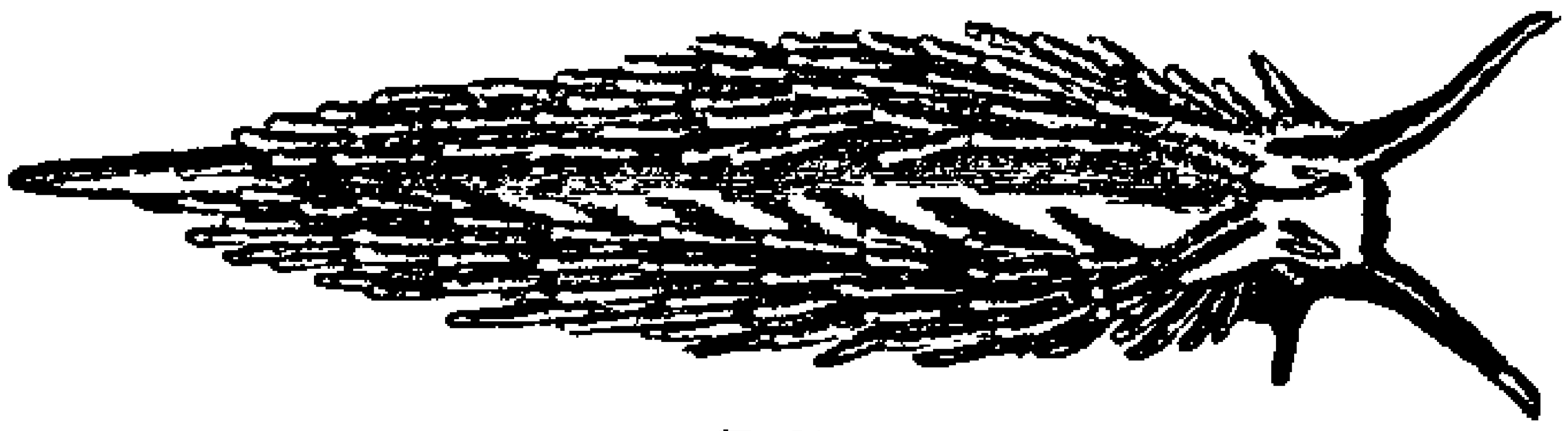


Scyllæa.

pods. In the Glauci and Scyllææ, we see at each side of the elongated body long arms branching out into tufty filaments; in the Briarei a hundred furcated stems serve for the aëration of the blood. On the back of the Eolides the gills are arranged in rows; in the Dorides they form a wreath or garland round the posterior intestinal aperture.

The beauty of these animals corresponds with their charming mythological names, for every part of them which is not

sparkling like the purest crystal shines with the liveliest colours, red, yellow, or azure. Some inhabit the coasts, where they creep along upon a well-developed foot, others live in the deep waters, where they cling to the stems of floating sea-weed with a narrow and furrowed foot, or swim upon their back, using the borders of the mantle and of the branchiæ as oars. Though chiefly living in the warmer latitudes, they are found in every sea, and many interesting species inhabit the British waters: such as the Sea-lemon (*Doris tuberculata*), which, when its horns and starry wreath of branchiæ are concealed, bears a curious resemblance in size, form, colour, and warty surface to the half of a citron divided longitudinally; the exquisite *Eolis coronata*, whose crowded clusters of branchial papillæ are radiant with crimson and cerulean tints; and the crested Antiopa, whose transparent breathing organs are tipped with silvery white.


Eolis.

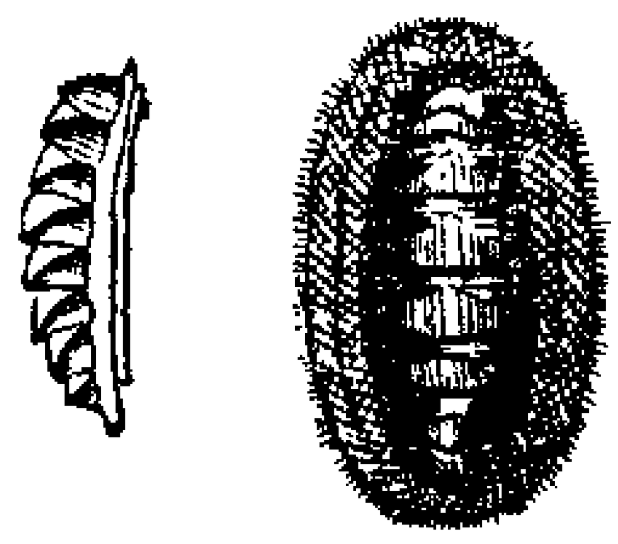
Though they have no shell to cover them, the Nudibranchiata are not left defenceless to the mercy of their enemies. The transparency of their body is a cause of safety to many of them. Some conceal themselves under stones or among the branches of the madrepores, and some on contracting cast off a part of their mantle, which they leave in possession of their hungry foe, while they themselves make their escape.

Among the British Inferobranchiata we find the rare golden or orange-coloured *Pleurobranchus plumula*, thus named from its branchiæ projecting like a plume from between the mantle and foot in crawling; and among the Tectibranchiata the common sea-hare (*Aplysia punctata*), which resembles a great naked snail; its back opening with two wide lobes, which can be expanded or closed over the opening at the animal's will. When open, they expose to view on the right side the finely fringed and lobed branchiæ, seated in a deep hollow beneath a fold of the mantle. The uncomely creature glides along over the stones upon its flat fleshy foot and up the slender stems of sea-weeds by bringing the borders of the same locomotive apparatus to

meet around the stem, thus tightly grasping it as if enclosed in a tube. While progressing, the fore part is poked forward as a narrow neck furnished with two pair of tentacles, one pair of which, standing erect and being formed of thin laminæ, bent round so as to bring the edges nearly into contact, look like the ears of the timid quadruped, from which the Aplysia has derived its common name. The colour is a dark-brownish purple studded with rings and spots of white. On being disturbed, the sea-hare pours out from beneath the mantle-lobes a copious fluid of the richest purple hue, which however quickly fades, and is of no value in the arts.

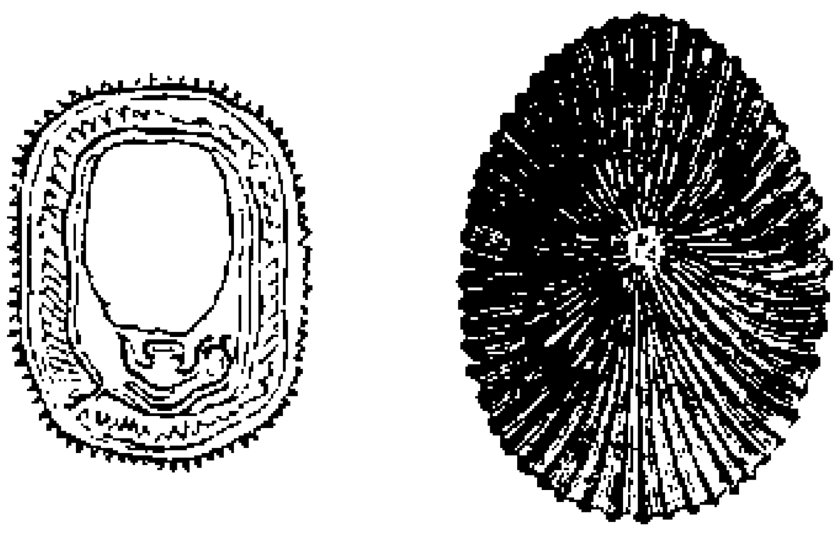
More than forty species of Aplysiæ are known, most of them inhabitants of the warmer seas. The acrid humour exuded by the depilatory aplysia, or *Aplysia depilans*, of the Mediterranean is still supposed by the Italian fishermen to occasion the loss of the hair, and was used by the ancient Romans in the composition of their venomous potions—though it is by no means poisonous. Such are the prejudices resulting from the propensity of man to associate evil qualities with an unprepossessing appearance.

To the Cyclobranchiate order belong the Limpets and the Chitons. The latter, which are the only multivalve shells among the Gasteropods, are spread in more than two hundred species over every shore from Iceland to the Indies, but they are particularly abundant on the coasts of Peru and Chili. Some of the smaller species inhabit our coasts, where they may be found adhering to stones near low water mark. They are coated with eight transverse shelly plates, folding over each other at their edges like the plates of ancient armour, and inserted into a tough marginal band, so as to form a complete shield to the animal. Thus encased in coat of mail, the chitons have the power of baffling the voracity of their enemies by rolling themselves up into a ball like the wood-louse or the armadillo: they are also able to cling with such tenacity to the rock that it is difficult to detach them without tearing them to pieces. The Limpets, or Patellæ, likewise attach their shield-like shell so firmly to a hard body that it requires the introduction of a knife between the shell and the stone to detach them. It has been calculated that the



Chiton squamosus.

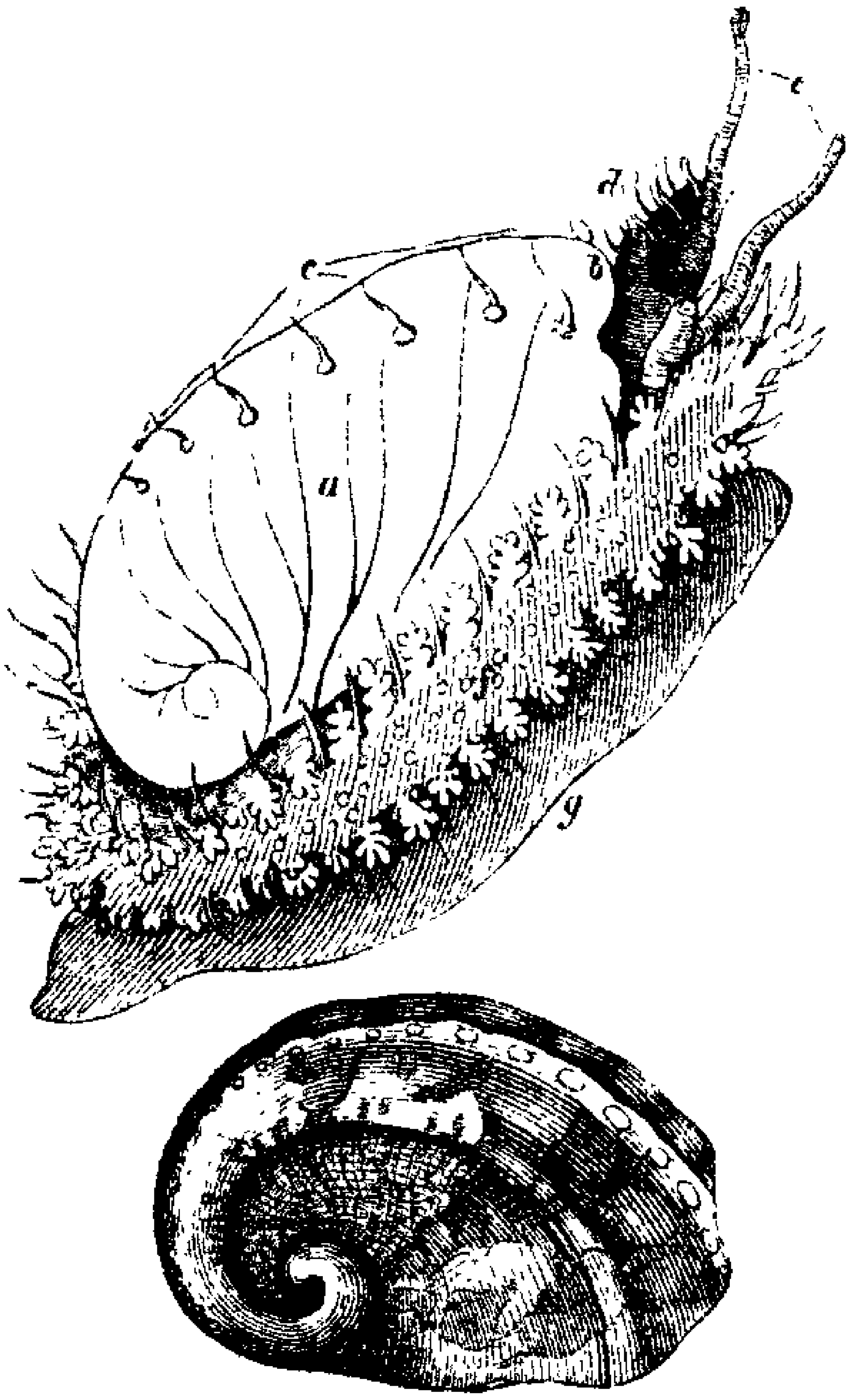
larger species are thus able to produce a resistance equivalent to a weight of 150 pounds, which, considering the sharp angle of the shell, is more than sufficient to defy the strength of a man to raise them. They often congregate in large numbers in one place, and an old writer compares them to nail-heads struck into the rock. More than a hundred species are known; one of which, the *Patella cochlear* of the Cape, is almost invariably found squatting upon the shell of another species of limpet. The finest and largest varieties abound on the shores of the Oriental seas and the coasts of the Mediterranean, but several of the smaller species are very numerous in our littoral or sub-littoral zone, where they either feast on the green sea-weeds that we find covering at ebb-tide the stones with a thin emerald layer, or upon the coarser olive-coloured algæ. Thus *Patella pellucida* and *Patella lævis*, both remarkable for longitudinal streaks of iridescent colours on an olive-shell, may generally be found feeding either on the broad fronds or on the roots and stems of the Laminariæ, or Oar-weeds. To their labours may indeed be partly attributed the annual destruction of these gigantic algæ, for, eating into the lower part of the stems, and destroying the branches of the roots, they so far weaken the base that it is unable to support the weight of the frond, and thus the plant is detached and driven on shore by the waves.



Limpet and Shell.

The beautiful Sea-ear, or Haliotis, is the chief representative of the scutibranchiate gasteropods. The flattened shell, perforated with small holes on one side, is characterised by a very wide mouth or aperture, the largest in any shell except the limpet. The outside is generally rough, or covered with marine substances; the inside presents the same enamelled appearance as mother-of-pearl, and exhibits the most beautiful colours. The holes with which the shell is perforated serve to admit water to the branchiæ, and are formed at regular intervals as it increases in size. The foot is very large, having the margin fringed all round, and is able, like that of the chiton or the limpet, to cling firmly to the rock. More than seventy species of Haliotis are known, the greater part occurring in the Pacific Ocean.

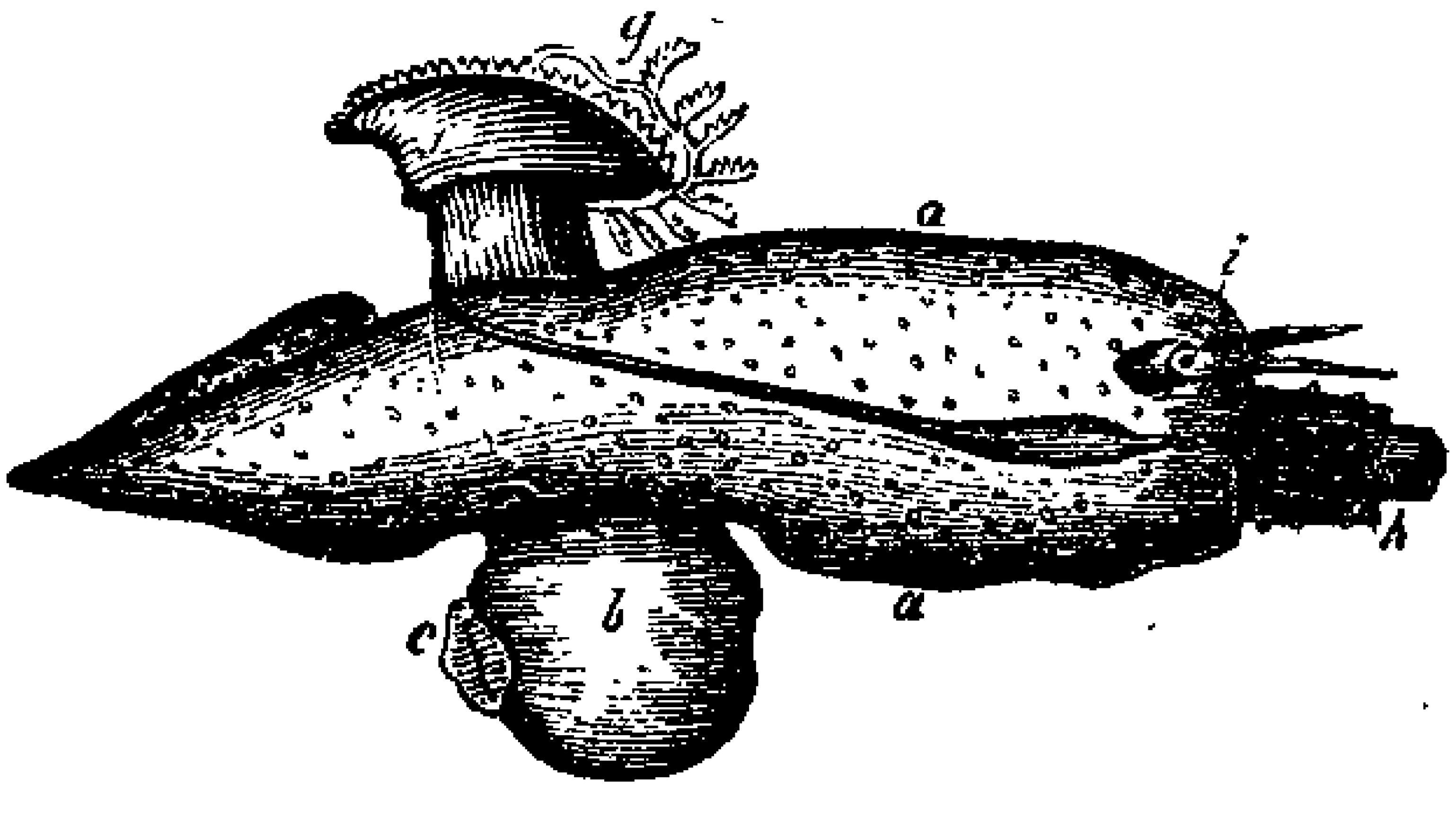
To the scutibranchiate gasteropods also belong the strangely formed Carinariæ, which seem to be made up of disjointed



Haliotis.

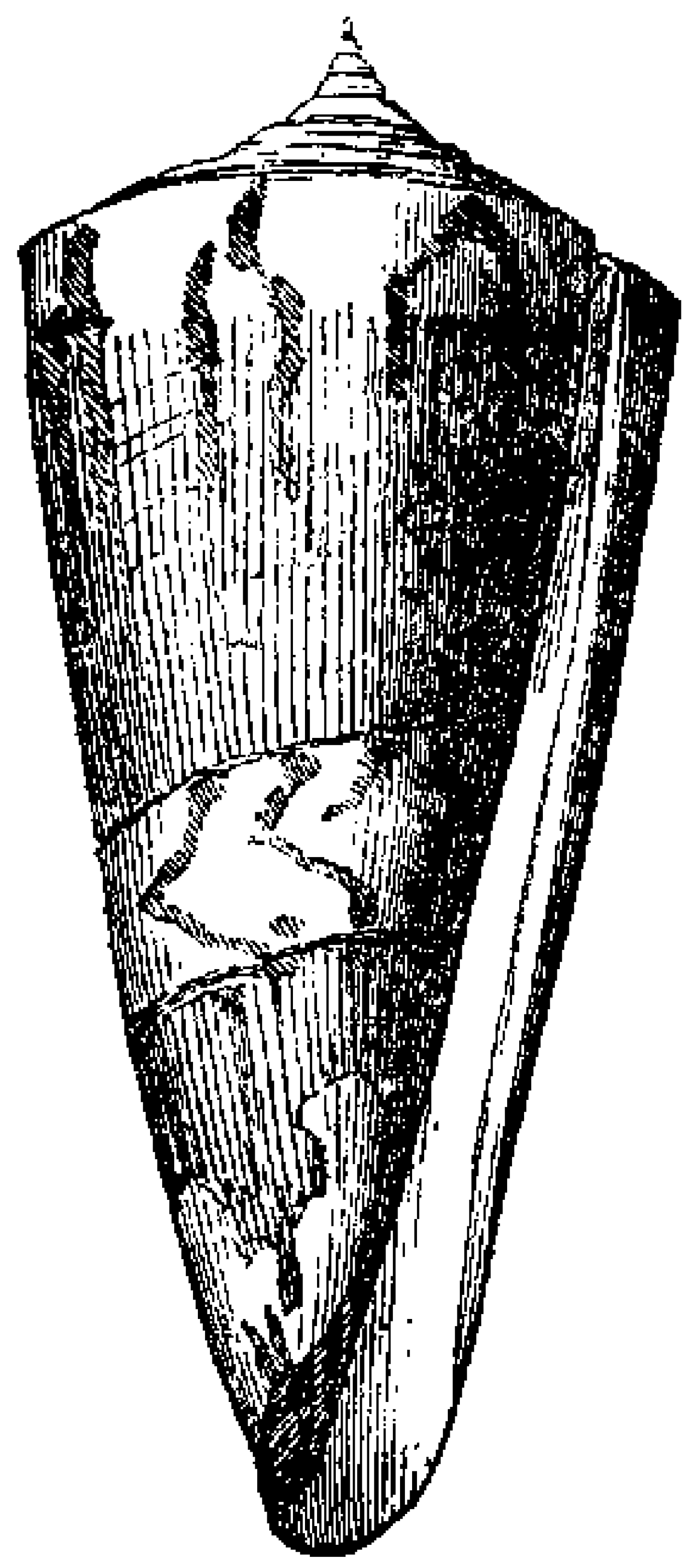
c. Series of perforations. d. Eye peduncles. e. Tentacles. g. Foot.

parts. The gills (*g*) project from under a thin vitreous shell (*f*), which projects from the dorsal surface, and has a form not unlike that of the Argonaut or of a Phrygian cap. The foot (*b*) is not formed for creeping, but constitutes a muscular vertical paddle or fin, that serves them for swimming on the back, and is furnished with a sucking disk (*c*), with which they are enabled to attach themselves to floating objects.

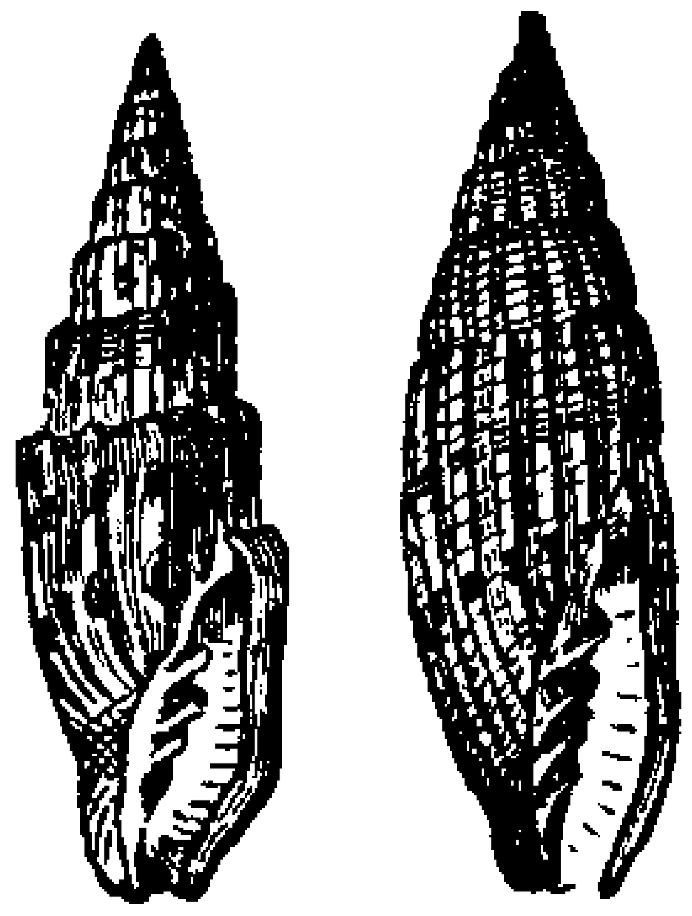


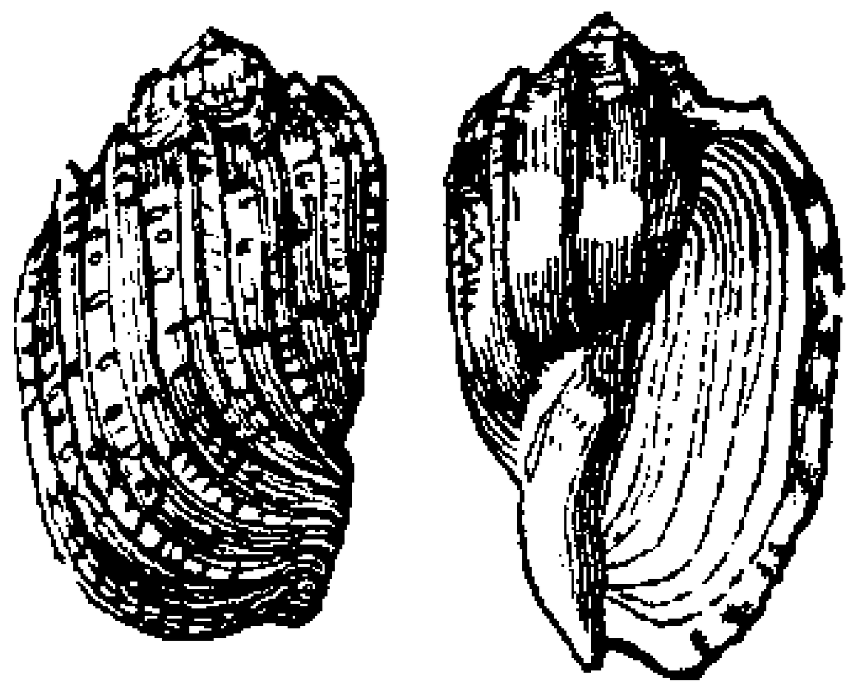
Carinaria.

The Pectinibranchiata comprise all the spiral univalve shells, and are by far the most numerous of all the gasteropods, as their species are not counted by hundreds, but by thousands. If their calcareous garment could be drawn out, it would be found to consist of a tube gradually widening from the apex to the base; but what an immense variety of form and ornaments, what a prodigality of splendid tints, has not Nature spread over this interminable host! The same fundamental idea appears to us in thousands of modifications, one yet more elegant and capricious than the other. Thus the passion of the shell collector is as conceivable as that of the lover of choice flowers, and when we read that rich tulip-amateurs have given thousands of florins for one single bulb, we cannot wonder that many of the Volutes, Cones, Mitres, and Harps, are worth several times their weight in gold; that more than a hundred pounds have been paid for a Chinese wentle-trap, and that the *Cypræa aurora*, which the Polynesian chiefs used to wear about the neck, is valued at thirty or forty guineas.


Orange Cone-Shell.

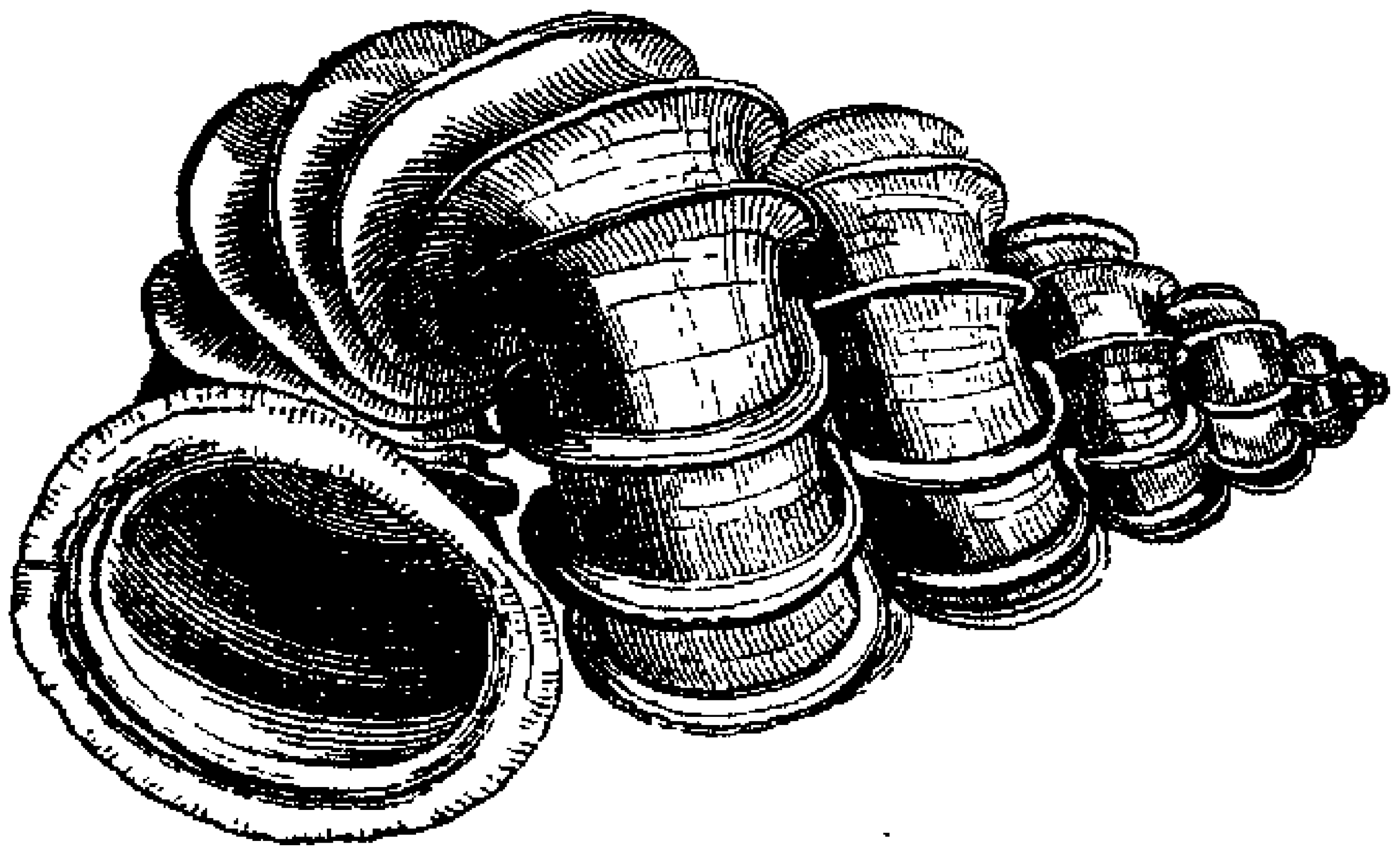
The mode in which these beautifully painted structures are formed is very similar to what takes place among bivalve shells. They are secreted by the glandular margin of the mantle or soft skin which clothes the upper part of the body of the snail,


Mitre-Shells.


Harp-shell.

and their form depends on the shape of the body they are destined to cover, while the outline of the border is alike regulated by that of the mantle. In the border of the mantle

are placed the glands through which colouring matter is added to the lime of which the shell consists, and here also the whole of the outer coat of the shell is formed by constant annual additions to the lip. The after-growth of the shell proceeds,



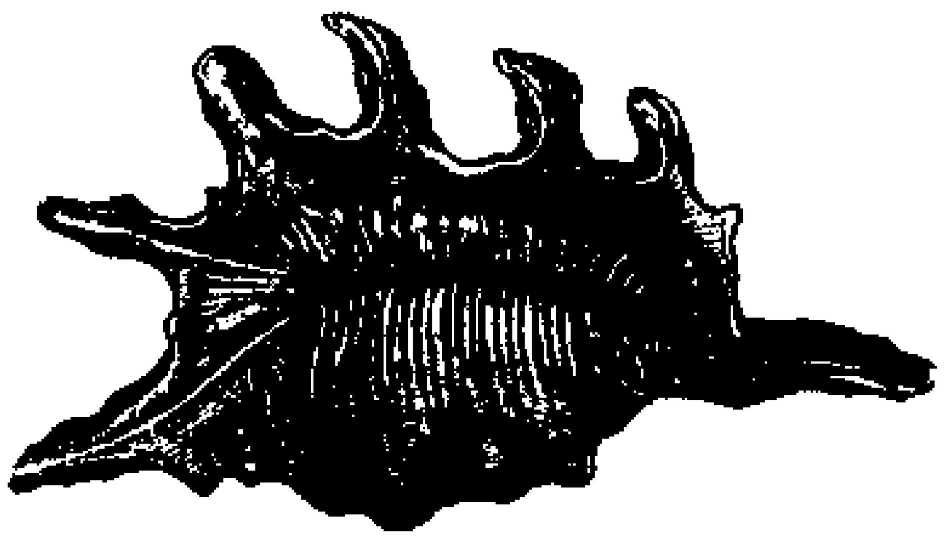
Chinese Wentle-trap.—(Scalaria pretiosa.)

layer over layer, from the general surface of the mantle, so that the calcareous robe constantly increases in thickness with the age of the animal.

However different the form of a shell may be, its use is invariably the same, affording the soft-bodied animal a shield or retreat against external injuries. In this respect it is not uninteresting to remark that those species which inhabit the littoral zone, and are most exposed to the violence of the waves, have a stronger shell than those which live in greater depths, and that the fresh-water molluscs have generally a much more delicate and fragile coat than those which live in the ocean. The greater the necessity of protection the better has Nature provided for the want. Thus most of the gasteropods, besides possessing a stone-hard dwelling, are also furnished at the extremity of the foot with an operculum, or calcareous lid, which fits exactly upon the opening of their house, and closes it like a fortress against the outer world. But no animal exists that is safe against every attack, for the large birds sometimes carry the ponderous sea-snails, whose entrance they cannot force with their beaks, high up into the air, and let them fall upon the rocks, where they are dashed to pieces.

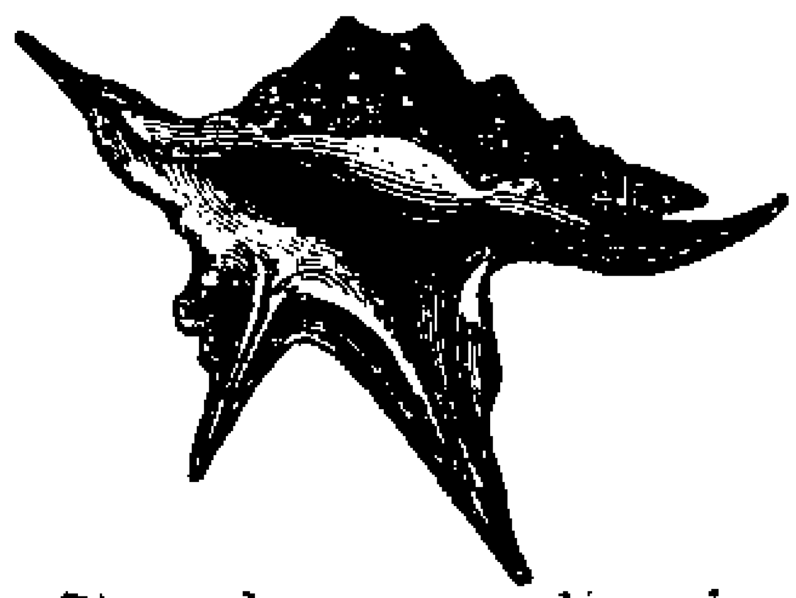
The ordinary mode of locomotion of the testaceous sea-snails

is by creeping along on their foot: those that have a very heavy house to carry, such as the Cassis or the Pteroceras, generally move along very slowly, while others, such as the Olivæ, that are possessed of a comparatively strong and broad foot, have rapid and lively movements, and quickly raise themselves again when they have been overturned. The Strombidæ and Rostellariæ place their powerful and elastic foot under the shell in a bent position, when suddenly by a muscular effort they straighten that organ and roll and leap over and over. The structure of the foot of the *Tornatella fasciata*, an inhabitant of our coast, is most remarkable: beaten incessantly by the waves, in the cavities of rocks which it frequents, nearly on a level with the surface of the sea, to the violence of which it is always exposed, it has need of additional powers for retaining its hold; its foot is therefore divided into two adhering portions, placed at each extremity, and separated by a wide interval; when it crawls, it fixes the posterior disc and advances the other, which it attaches firmly to the place of progression, and this being effected, the hinder sucker is detached and drawn forwards, locomotion being accomplished by the alternate adhesion of these two prehensile discs. In Cyclostoma the foot is likewise furnished with two longitudinal adhering lobes, which are advanced alternately. But the foot of the marine snails is not merely an instrument of progression on a solid surface, for in many species it is convertible at the will of the animal into a boat, by means of which the creature can suspend itself in an inverted position at the surface of the water, where by the aid of its mantle and tentacles it can row itself from place to place.

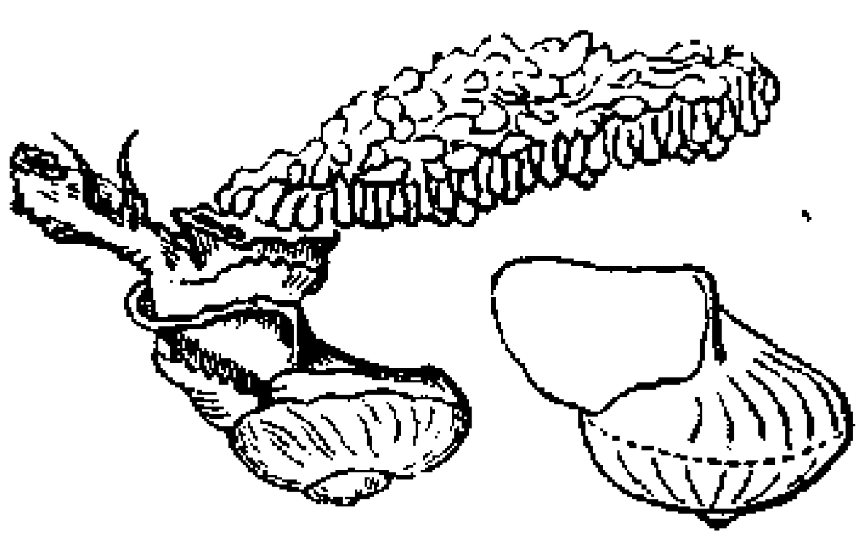


Pteroceras scorpio.

Oliva hispidula.



Strombus pes pelicani.



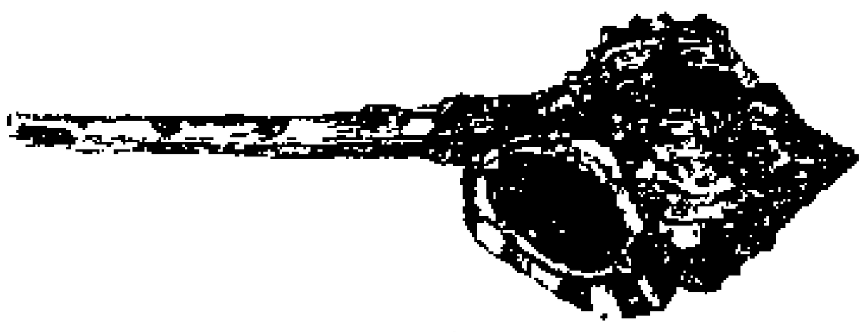
Ianthina communis.

The Ianthinæ, or purple Sea-Snails, carry under their foot a vesicular organ like a congeries of foam-bubbles, that prevents creeping, but serves as a buoy to support them at the surface of the water.

When the sea is quiet, these little creatures,

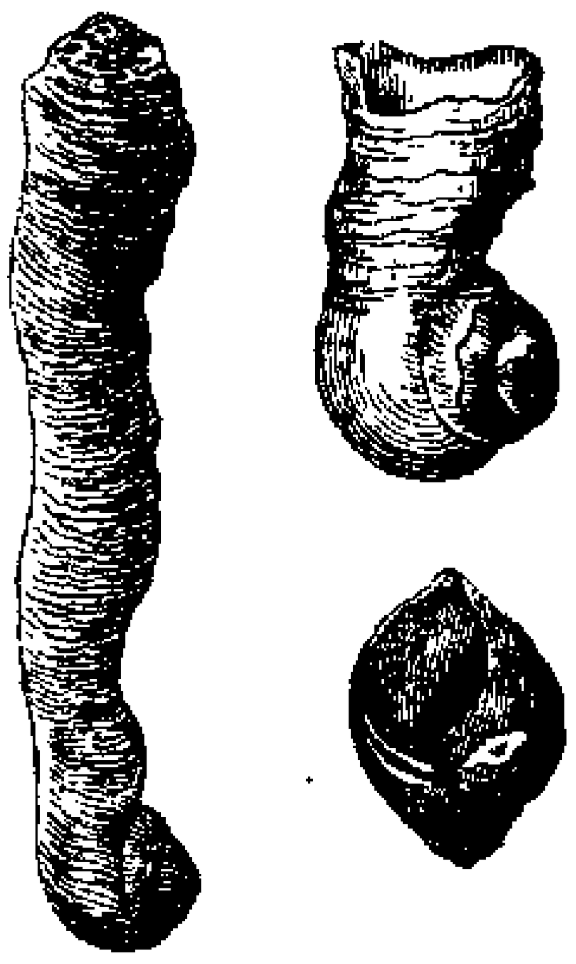
Like little wanton boys that swim on bladders,

appear in vast shoals on the surface, but as soon as the wind ruffles the ocean, or an enemy approaches, they at once empty their air-cells, contract their float, and sink to the bottom, pouring out at the same time a darkened fluid like that of the Aplysia or the Murex, which no doubt serves them as a defence against their foes, and, according to Lesson, furnished the celebrated purple of the ancients. The Ianthinæ inhabit the Mediterranean and the warmer regions of the Atlantic, but especially towards the close of summer they are frequently drifted by the Gulf Stream to the west coast of Ireland.



Murex haustellum.

While the vast majority of the gasteropods either creep or swim, some are doomed to the sedentary life of the oyster, and remain for ever fixed to the spot where they first attached themselves as small free-swimming larvæ. Thus the *Magilus antiquus*, which in its young state presents all the characters of a regular spiral univalve, establishes itself in the excavations of madrepores, and as the coral increases around it, the Magilus is obliged, in order to have its aperture on a level with the surrounding surface, to construct a tube, lengthening with the growth of the coral. As the tube goes on increasing, the animal abandons the spiral for the tubular part of the shell, and in the operation it leaves behind no partitions, but secretes a compact calcareous matter which reaches to the very summit of the spiral part, so that in an old specimen the posterior part of the shell presents a solid mass.



Magilus antiquus.

The Siliquariæ are generally found embedded in a similar manner in sponges or other soft bodies, while the Vermetus, or Worm-Shell, usually attaches itself, like the Serpulæ, to rocks, coral-reefs, or shells.

Worm-Shell.

In these genera, which have been arranged by Cuvier in a separate order (Tubulibranchiata), the foot is naturally reduced to the state of an adhesive organ, its chief functions consisting in opening and closing the lid.

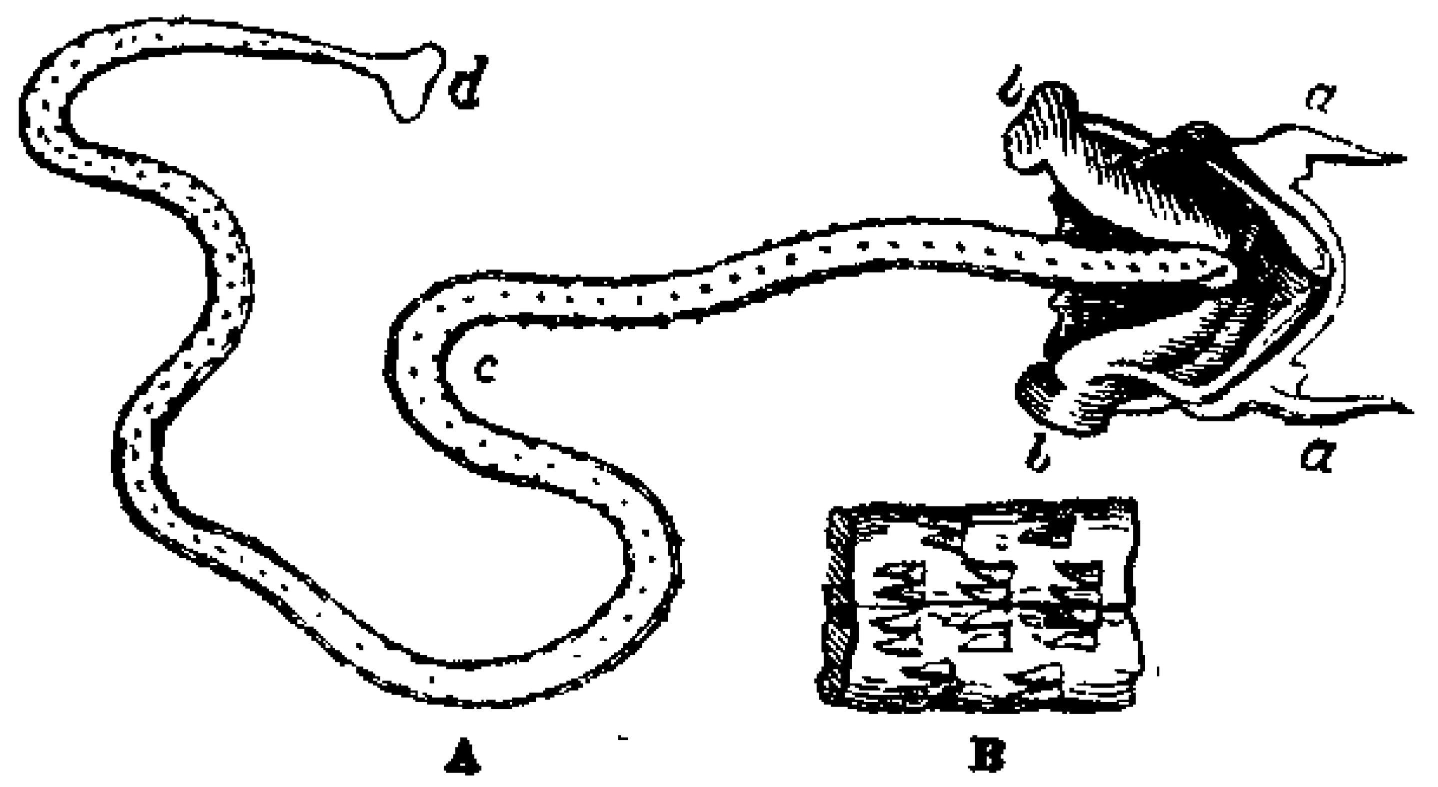
The sea-snails are either predaceous or herbivorous; among the pectinibranchiates, those with circular mouths to the shell are vegetable feeders, while such as have an aperture ending in a canal are animal feeders. Considerable modifications of internal structure indicate this difference of food; and the external organs, particularly about the mouth, exhibit a corresponding variety of form. In those which feed on vegetables the mouth is generally a slit furnished with more or less perfect lips, armed with a simple cutting apparatus, which is often powerful enough to divide or dismember comparatively hard substances.

In most animal feeders the mouth presents the appearance of a proboscis that can be protruded or shortened at the will of the animal, and which, grasping the food, conveys it to a spine-armed tongue, by the aid of which it is propelled into the gullet without mastication or any preparatory change.

In the Whelk and its shell-boring allies, the alternate protrusion and retraction of the proboscis, which is here of a much more complicated structure, causes the sharp tongue to act as a rasp or auger, capable of drilling holes into the hardest shells. It is this circumstance which renders the whelk so formidable an enemy to mussel and oyster banks. During the erection of Bell-rock lighthouse, an attempt was made to plant a colony of mussels on the wave-beaten cliff, as they were likely to be of great use to the workmen, and especially to the light keepers, the future inhabitants of the rock; but the mussels were soon observed to open and die in great numbers. "For some time," says Mr. Stevenson in his interesting narrative, "this was ascribed to the effects of the violent surge of the sea, but the Buccinum lapillus having greatly increased, it was ascertained that it had proved a successful enemy to the mussel. The buccinum was observed to perforate a small hole in the shell, and thus to suck out the finer parts of the body of the mussel; the valves of course opened, and the remainder of the shell-fish was washed away by the sea. The perforated hole is generally

upon the thinnest part of the shell, and is perfectly circular, of a champhered form, being wider towards the outward side, and so perfectly smooth and regular as to have all the appearance of the most beautiful work of an expert artist. It became a matter extremely desirable to preserve the mussel, and it seemed practicable to extirpate the buccinum. But after we had picked up and destroyed many barrels of them, their extirpation was at length given up as a hopeless task. The mussels were consequently abandoned as their prey; and, in the course of the third year's operations, so successful had the ravages of the buccinum been that not a single member of the imported mussel colony was to be found upon the rock." Thus the engineer, whose skill and perseverance had gained so proud a triumph over the waves of the stormy ocean, was defeated by an ignoble whelk.

In the genera which have no proboscis, the tongue, acting as a prehensile and rasping or abrading organ, is frequently of considerable length; thus, in the Ear-shell, it is half as long as the body, and in the common Limpet even three times longer than the entire animal. From the two cartilaginous pieces (*b b*), placed on each side of its root, arise the short and powerful muscles which wield the organ. The surface of this curious piece of mechanism, a magnified view of which is given at B, is armed with minute, though strong, teeth, placed in transverse rows, and arranged in three series; each central group consists of four spines, while those on the sides contain but two a-piece. It is only at its anterior extremity (*d*), however, that the tongue, so armed, presents that horny hardness needful for the performance of its functions, the posterior part being comparatively soft; so that, probably in proportion as the anterior part is worn away, the parts behind it gradually assume the necessary firmness, and advance to supply its place. In the upper part of the circumference of the mouth, we find a semicircular horny

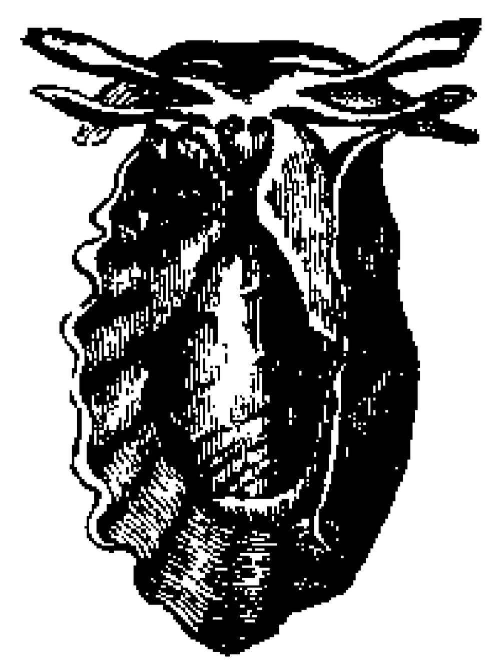


Limpet's tongue.

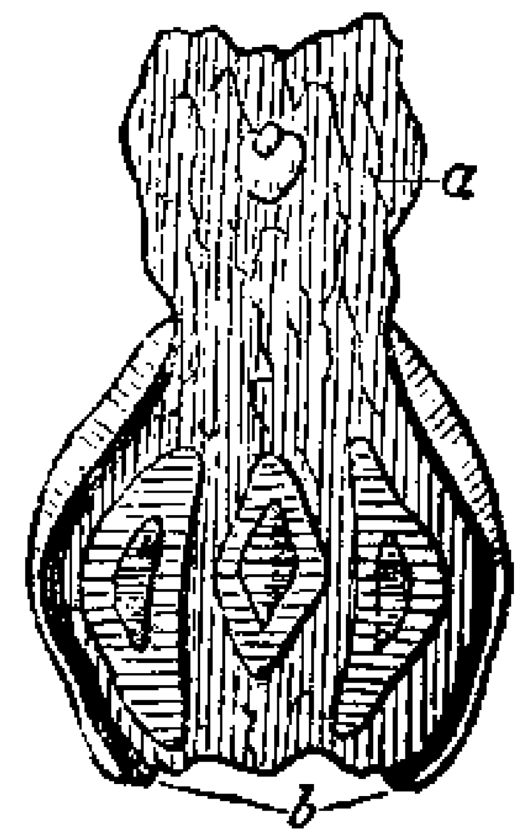
plate, resembling an upper jaw, and the tongue, by triturating the food against this, gradually reduces substances however hard. On opening the limpet, the tongue is found doubled upon itself, and folded in a spiral manner beneath the viscera.

Many of the Gasteropods which live on coarse and refractory materials are provided with several digestive cavities, resembling in some degree the stomachs of the ruminating quadrupeds; and frequently the triturating power of these organs is still further increased by their being armed with teeth variously disposed.

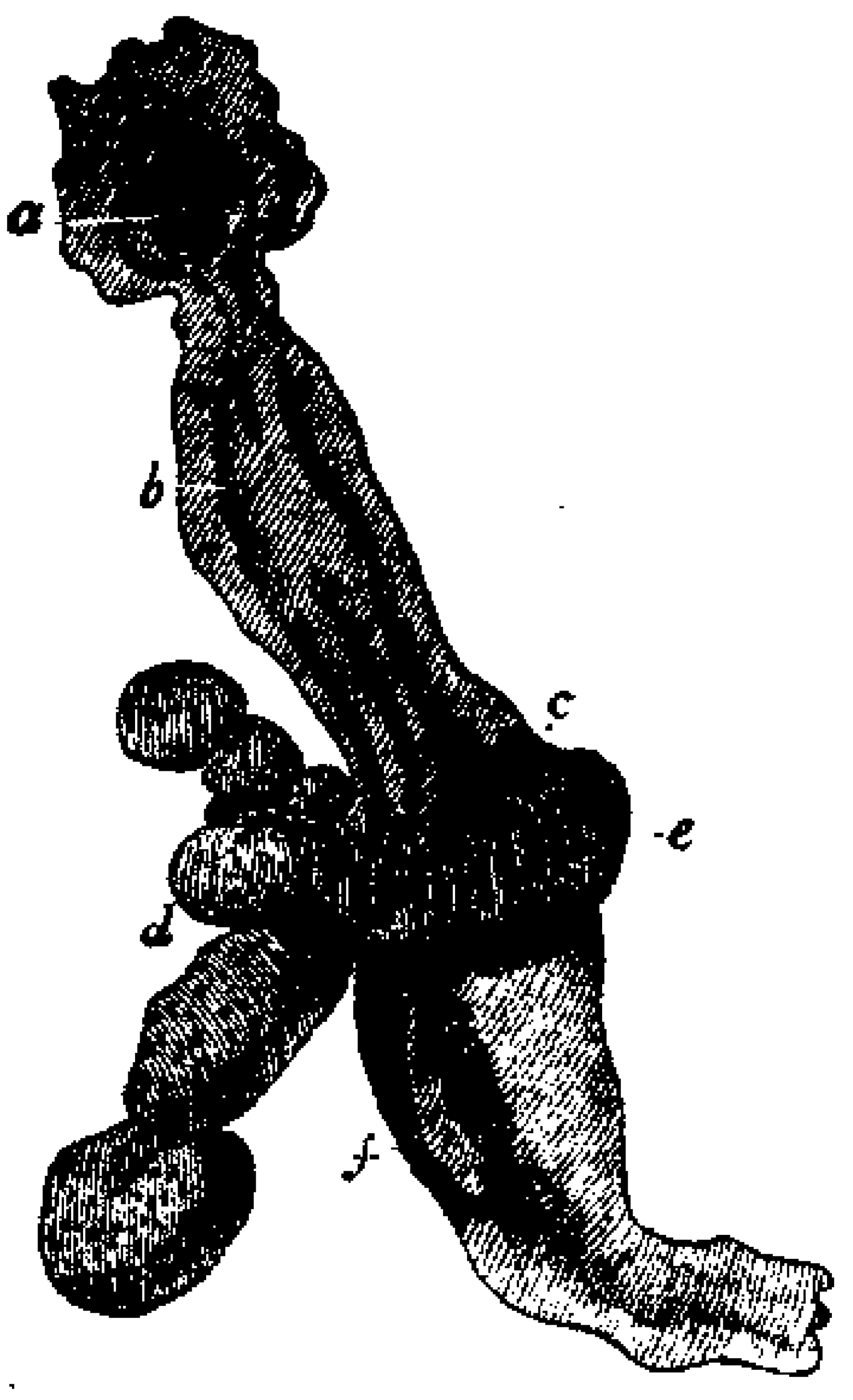
In the Bulla, for instance, a genus belonging, like the sea-hares, to the tectibranchiate order, the gizzard, or second stomach, contains three plates of stony hardness attached to its walls, and so disposed that they perform the part of a most efficacious grinding mill.


Bulla.

On opening the gizzard of the Scyllæa, it is found to be still more formidably armed, for in its muscular walls there are embedded no less than twelve horny plates (*e*), which are extremely hard and as sharp as the blades of a knife.



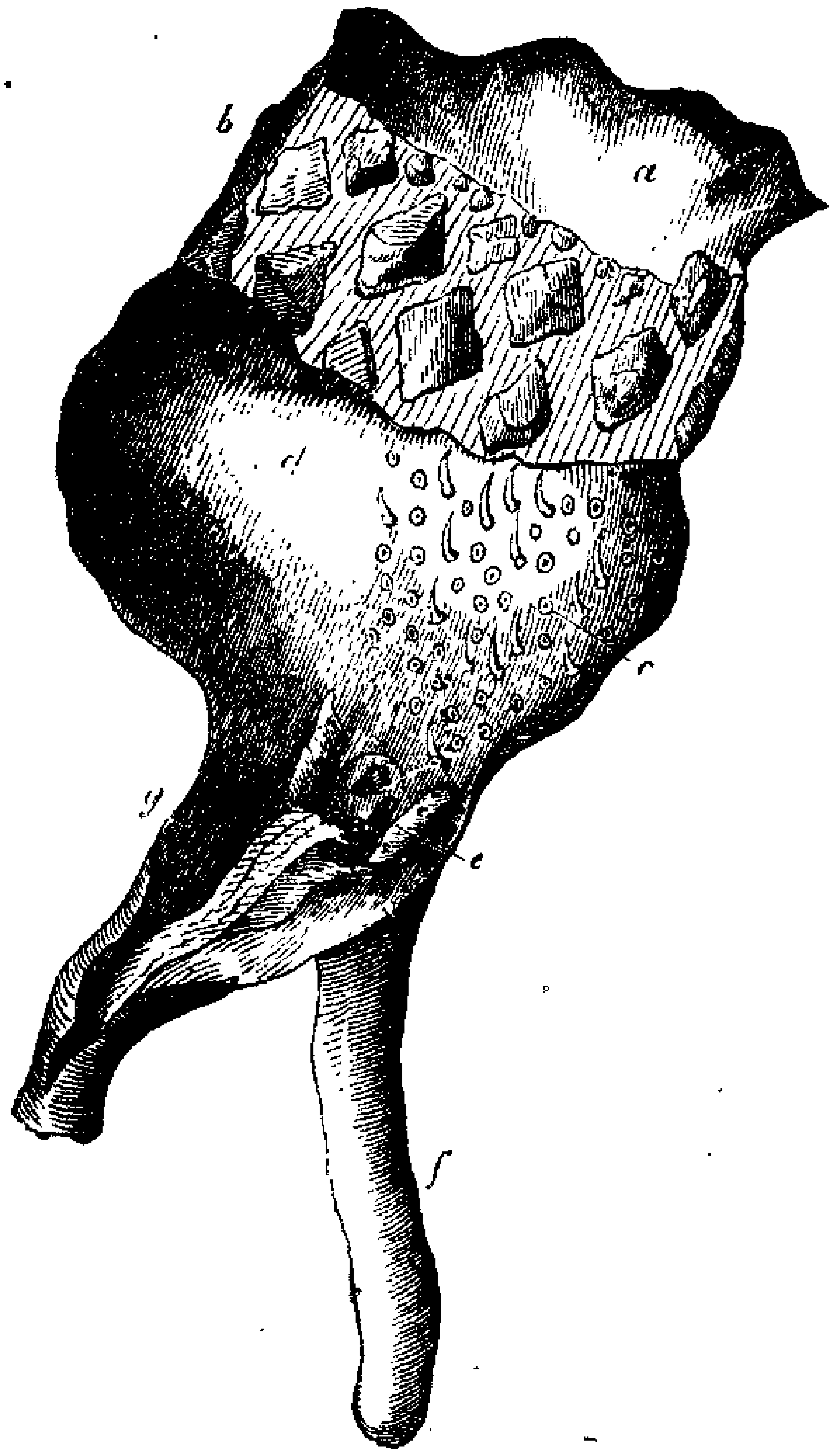
Gizzard of Bulla.



Gizzard of Syllæa.

The Sea-hare, however, furnishes us with the most curious form of these stomachal teeth, for here we see not only the gizzard (*b*) armed with horny pyramidal plates, whose tuberculated apices, meeting in the centre of the organ, must necessarily bruise by their action whatever passes through that cavity, but the third stomach (*d*) is also studded with sharp-pointed hooks (*c*), resembling canine teeth, and admirably adapted to pierce and subdivide the tough leathery fronds of the olive sea-weeds on which the animal feeds. Thus these deformed and disgusting molluscs afford us one of the most interesting examples of the adaptation of organs to their

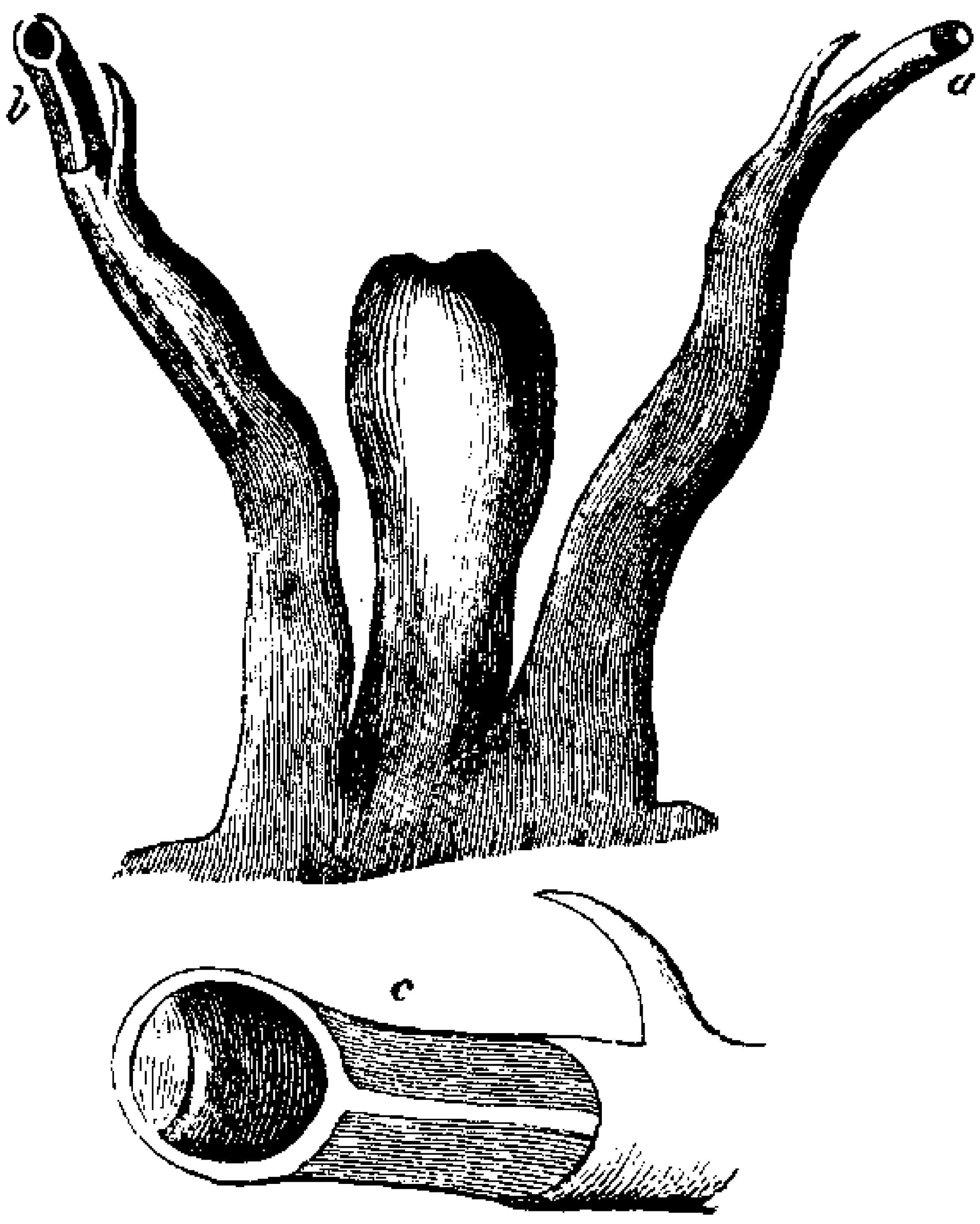
functions, which an enlightened research is continually finding in creation.



Compound stomach of Sea-Hare.

Though not so gifted as the cephalopods, many of the gasteropods possess all the organs of sense. Like them, they have an apparatus specially calculated to appreciate sonorous undulations, and consisting of a membranous vesicle attached to an auditive nerve, and containing either a single spherical otolithe or a larger number of similar smaller calcareous bodies, which by their vibrations communicate the impression of sound to the nerve. Their minute eyes are short-sighted, it is true, and frequently either entirely wanting or, as in the Nudibranchiates, scarcely able to distinguish light from darkness; but their inactive habits require no wide field of vision, and thus they see as much of the external world as is necessary for their

humble sphere of existence. The organs of sight are generally situated either on a prominence at the base of the superior pair of tentacles or, as, for instance, in the Murex, at the extremity of these organs (*a*, *b*), a position which enables the animal to direct them readily to different objects.



Tentacles and eye of Murex.
c. Eye highly magnified.

Many of the Gasteropods are evidently capable of perceiving odours; thus, animal substances let down in a net to the bottom will attract thousands of Nassæ in one night. We also may infer that they are not deficient in taste from the presence of papillæ at the bottom of their mouth, analogous to those found on the tongue of other animals; but, of all their senses, that of touch is undoubtedly the most perfect. The whole soft surface of the body is indeed of exquisite sensibility, but more especially the vascular foot, and the tentacles, or horns, which vary both in number and in shape in different genera. Yet, in spite of this delicacy in the organisation of the skin, which makes it so sensible of contact, it appears to have been beneficently ordered that animals so helpless and exposed to injury from every quarter are but little sensible to pain. Although they are deprived of all higher instincts, we find among the Gasteropods a few examples of concealment under extraneous objects, which remind us of the masks and artifices frequently employed by the insects and crustaceans.

The Agglutinating Top (*Trochus agglutinans*) covers itself with small stones and fragments of shells, and thus shielded from the view escapes the voracity of many an enemy but little suspecting the savoury morsel hidden under the mound of rubbish which he disdainfully passes by.

In animals which are only provided with passive means of

defence, we may naturally expect a considerable degree of caution, and in this respect the gasteropods might give many useful lessons to man. How carefully they protrude their tentacles as far as possible to sound every obstacle in their way, before they creep onwards, and how rapidly they withdraw into their shell at the least symptom of danger! What an example to so many of us that leap before they look, and frequently break their necks in the fall!

Yet, in spite of all their prudence and of the protection of their stony dwellings, they serve as food to a host of powerful enemies. The sea-stars, their most dangerous foes, not only swallow the young fry but also seize with their long rays the full-grown gasteropods, and clasp them in a murderous embrace.

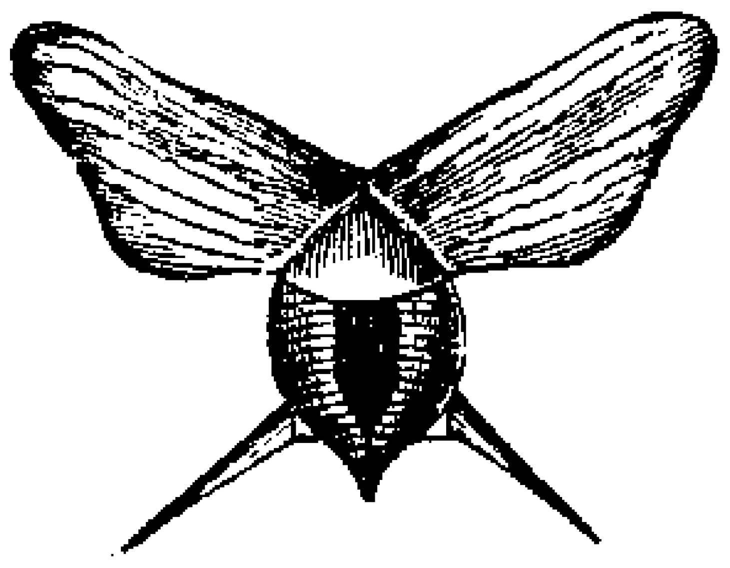
They are preyed upon by fishes, crustaceans, and sea-birds, who pick them up along the shores; but it will sometimes happen that a crow, while endeavouring to detach a limpet for its food, is caught by the tip of its bill, and held there until drowned by the advancing tide.

Man also consumes a vast number of sea-snails, for on every coast there are some edible species; and it may be said that, with the exception of very few that have a disagreeable taste, they are all of them used as food by the savage. The miserable inhabitants of Tierra del Fuego chiefly live upon a large limpet that abounds on the rocky shores of their inhospitable land, and but for this resource would most likely long since have been extirpated by hunger.

Many of the univalve shells are, moreover, highly prized as objects of ornament or use both by savage and civilised nations. The South Sea Islander makes use of a Triton as a war conch; the Patagonian drinks out of the Magellanic volute, the Arab of the Red Sea employs a large Buccinum as a water-jug, and the *Cypræa moneta* is well-known in commerce as the current coin of the natives of many parts of Africa. In Europe the iridescent Haliotis is frequently used for the inlaying of tables or boxes, and various species of Helmet-shells and Strombi (*Cassis rufa madagascariensis, Strombus gigas*), peculiar as being formed of several differently coloured layers, placed side by side, are in great request for the cutting of cameos, as they are soft enough to be worked with ease, and hard enough to resist wear. More than two hundred thousand of these shells are annually

imported into France, and the value of cameos produced in Paris alone amounts to more than a hundred thousand pounds. A large number are also cut in the small town of Oberstein on the Nahe (a river flowing into the Rhine at Bingen), which has long been famous for the manufactory of agate ornaments and trinkets, and has now added this new branch of industry to the more ancient sources of its prosperity.

The Pteropods, or Wing-footers, move about by means of two fin-like flaps, proceeding wing-like from the fore part of the body. They have no disk to walk upon, nor arms for the seizure of prey, like the cephalopods and gasteropods, but resemble them by the possession of a head distinct from the rest of the body, which some, like the Hyaleas and Cleodoras, conceal in a thin transparent or translucent shell, in which they also hide their head and wings at the approach of danger, and immediately sink to the bottom; while others, like the blue and violet Clios, beautifully variegated with light red spots, are perfectly naked. They generally inhabit the high seas, and are but rarely drifted by storms or currents into the neighbourhood of the land. They mostly swim about freely, but sometimes also they are found clinging by their wings to floating sea-weeds. They are small creatures, but propagate so fast that the *Clio borealis* and *Limacina arctica* form the chief food of the colossal whale.


Hyalea globulosa.

While these two little pteropods, in spite of their minute proportions, deserve to rank among the most important inhabitants of the northern seas, the Mediterranean species belong mainly to the genera Hyalea, Cleodora, and Criseis—forms wholly unknown to our own fauna except as waifs. Vast shoals of these animals frequent the deeper parts of that sea, leaving their remains strewed over its bed, between depths of from one hundred to two hundred fathoms; they are short-lived creatures, and have their seasons, being met with near the

surface during spring and winter, sparkling in the water like needles of glass.

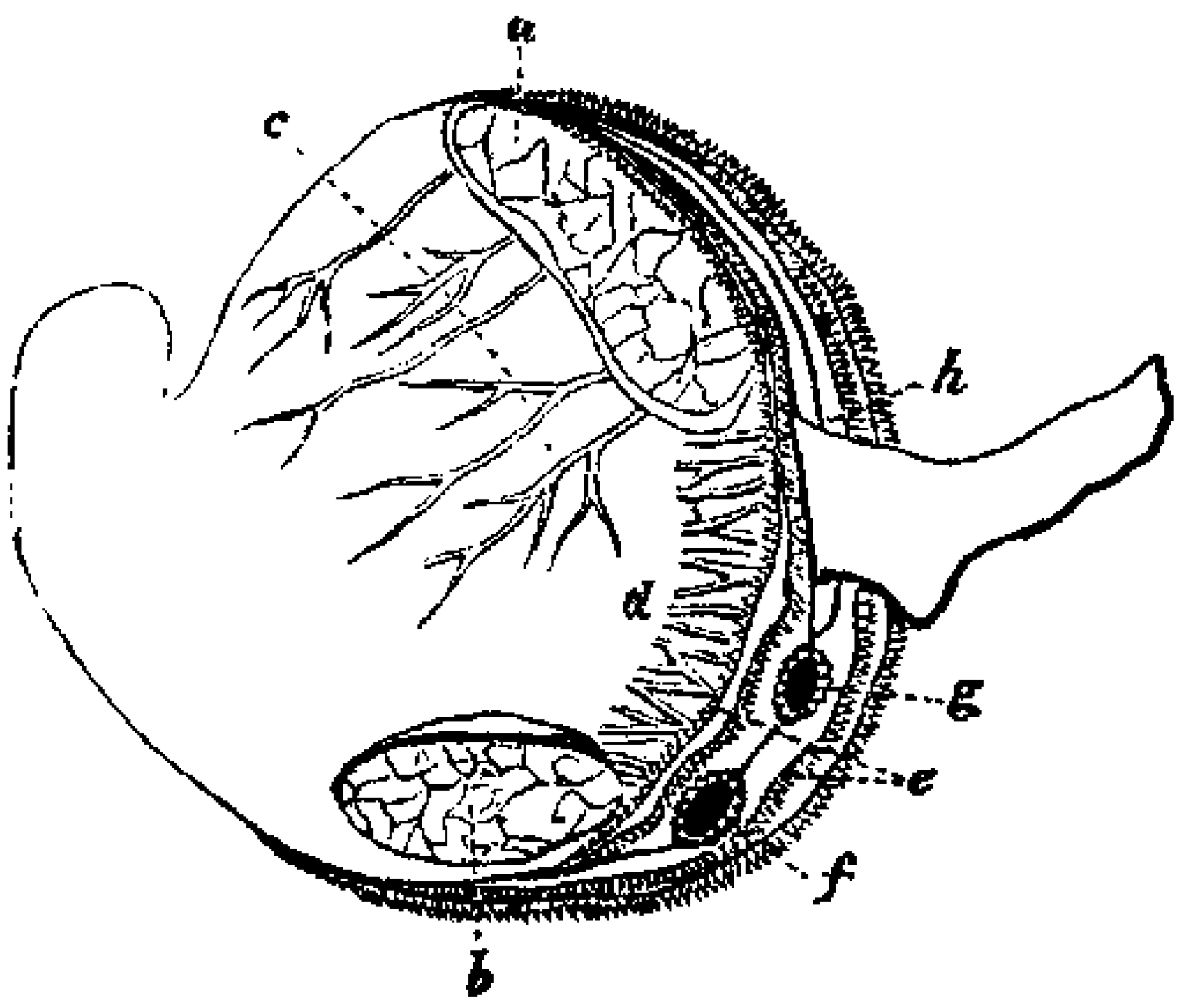
"The pteropods are the winged insects of the sea," says M. Godwin-Austen, "reminding us, in their free circling movements and crepuscular habits, of the gnats and moths of the atmosphere; they shun the light, and if the sun is bright, you may look in vain for them during the life-long day—as days sometimes are at sea; a passing cloud, however, suffices to bring some Cleodoræ to the surface. It is only as day declines that their true time begins, and thence onwards the watches of the night may be kept by observing the contents of the towing-net, as the hours of a summer day may be by the floral dial. The Cleodoræ are the earliest risers; as the sun sets, *Hyalœa gibbosa* appears, darting about as if it had not a moment to spare, and, indeed, its period is brief, lasting only for the Mediterranean twilight. Then it is that *Hyalœa trispinosa* and *Cleodora subula* come up; *Hyalœa tridentata*, though it does not venture out till dusk, retires early, whilst some species, such as *Cleodora pyramidata*, are to be met with only during the midnight hours and the darkest nights. This tribe, like a higher one, has its few irregular spirits, who manage to keep it up the whole night through. All, however, are back to their homes below before dawn surprises them."

The lamellibranchiate Acephala, or headless molluscs with comb-like gills, are distinguished from the preceding orders of molluscs by a more simple organisation and the peculiar formation of their external coverings. They are all contained within a bivalve shell, articulated after the manner of a hinge, and to which some of their families are attached by one strong muscle (Monomyaria), others by two (Dimyaria). In this shell, which is secreted by two large flaps or folds of their skin or mantle, they generally lie concealed like a book in its binding, and bid defiance to many of their enemies. When danger menaces, the sea-snail withdraws its head and closes the entrance of its hermitage with a lid, but the bivalve shuts its folding-doors when it wishes to avoid a disagreeable intruder. A strong elastic

ligament connects the two valves, and opens them wide as soon as the muscular contraction which closed them ceases to act.

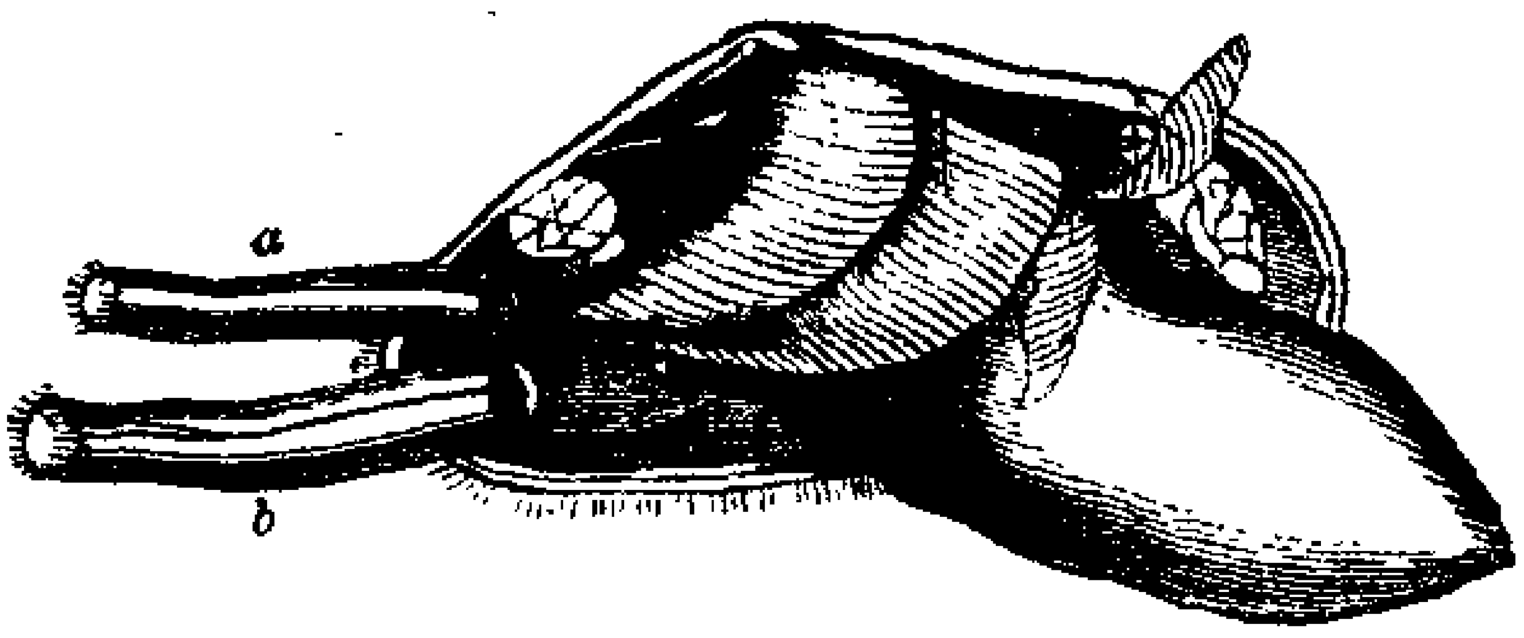
While the sea-snail creeps along upon a mighty foot, the bivalve is frequently doomed to a sedentary life, and the former protrudes from its shell a well-formed head, while the latter, like many a biped, has no head at all. The lamellibranchiate Acephala have, however, been treated by nature not quite so step-motherly as might be supposed from this deficiency, for many of them have eyes, or at least ocular spots, which enable them to distinguish light from darkness; and even auditory organs have been discovered in many of them. Their circulation is performed by a heart generally symmetrical, and their respiration by means of four branchial leaflets equal in size, and symmetrically arranged on either side of the body. The mouth is a simple orifice without any teeth, bordered by membranous lips, and placed at one end of the body between the two inner leaves of the branchiæ. The digestive apparatus consists of a stomach or intestine of different lengths, a liver, and several other accessory organs. A simple nervous system brings all the parts of the body into harmonious action.

In many lamellibranchiates the folds of the mantle are disjoined, as, for instance, in the oyster, which, on opening its shell, at once admits the water to its delicately fringed branchiæ; in others they are more or less united, so as to form a closed sack with several openings, an anterior one (*h*) for the passage of the foot, and two posterior ones (*g*, *f*) for the ingress and egress of the water which the animal requires for respiration. These posterior openings are often prolonged into shorter or longer tubes or siphons, sometimes separate, and sometimes grown together so as to form a single elongated fleshy mass. The use of these prolongations becomes at once apparent when we consider that they are chiefly developed in those species which burrow in sand, mud, wood, or stone, and which therefore require to



Bivalve deprived of shell, to show its various openings.

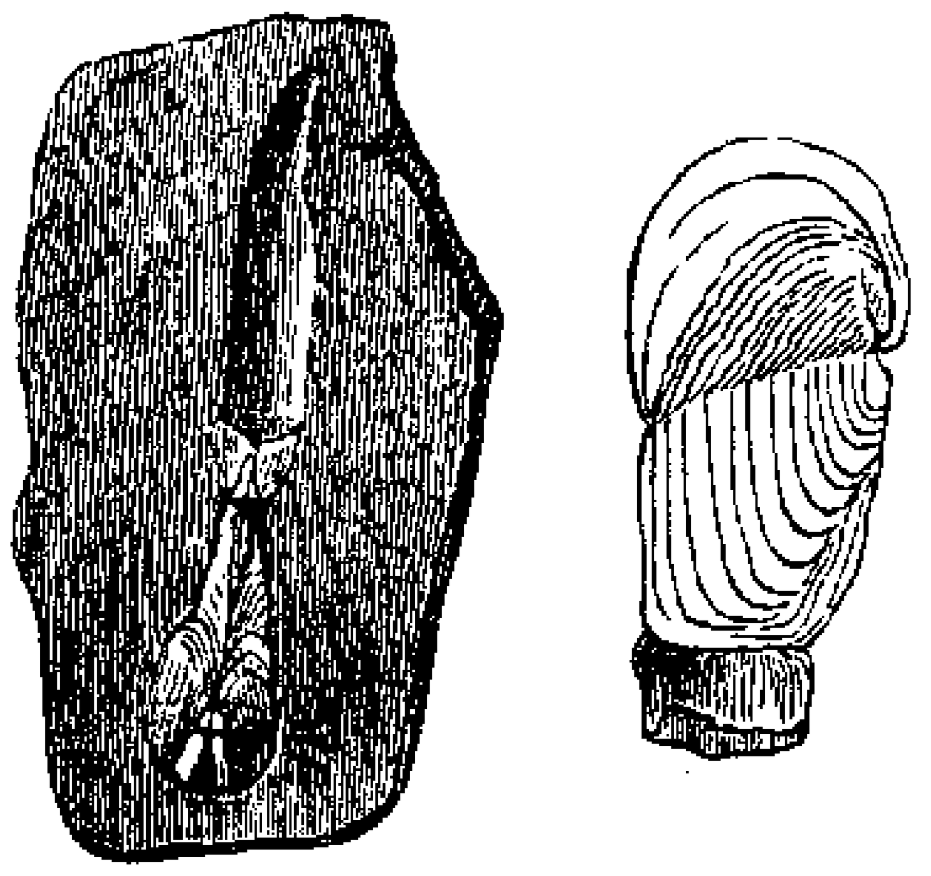
be specially guarded against the danger of suffocation. The interior of these siphonal canals is lined with innumerable vibratory cilia, by the action of which the water is drawn towards the branchial orifice and conveyed in a current through the canal over the surface of the gills; then, having been deprived of its oxygen, it is expelled by a similar mechanism through the other tube; and it is by the force of this anal current that the passage is kept free from the deposit of mud or other substances, which would otherwise soon choke it up. The cleansing action of the anal current is assisted by the faculty the burrowing molluscs possess of elongating and contracting their siphons, and the degree to which this may be accomplished depends on the depth of the cavity which the species is accustomed to make. Yet since many particles of matter float even in clear water, which from their form or other qualities might be injurious to the delicate tissue of the viscera to be traversed, how is the entrance of these to be guarded against in an indiscriminating current? A beautiful contrivance is provided for this necessity. The margin of the branchial siphon, and sometimes, though more rarely, of the anal one, is set round with a number of short tentacular processes, endowed with an exquisite sensibility and expanding like feathery leaves. In *Pholas dactylus* this apparatus, which is here confined to the oral tube, is of peculiar beauty, forming a network of exquisite tracery, through the interstices or meshes of which the water freely percolates, while they exclude all except the most minute floating atoms of extraneous matter. Thus admirably has the health and comfort of the lowly shellfish been provided for that spend their whole life buried in sepulchres of stone or sand.



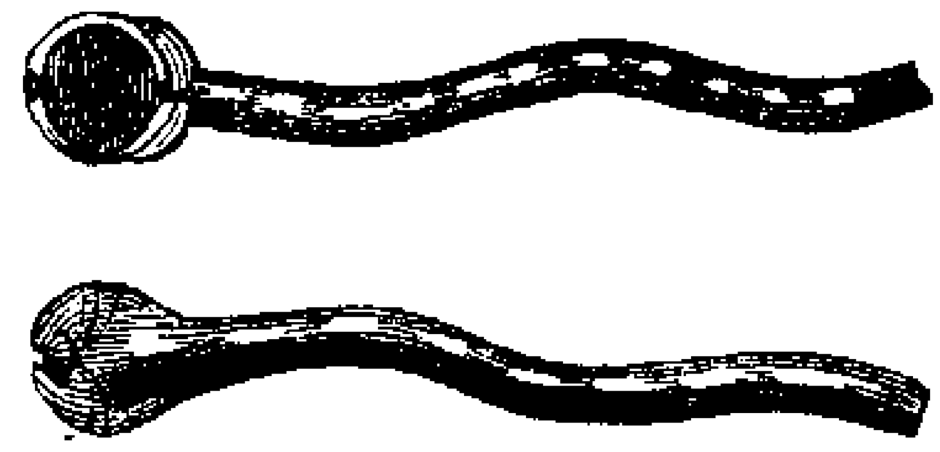
Donax.
a, b. Siphons.

The fragile shell of the pholades seems to have prompted them to seek a better protection in the hard rock; a similar necessity may have induced the shipworm to drill a dwelling in wood. Its shells, which are only a few lines broad, are very small compared with the size of the vermiform body, and are

therefore completely inadequate for its defence. For better security it bores deep passages in submerged timber, which it lines with a calcareous secretion, closing the opening with two small lids. Unfortunately, while thus taking care of itself, it causes considerable damage to the works of man. It is principally to guard against the attacks of this worm that ships are sheathed with copper, and the beams of submarine constructions closely studded with nails. During the last century, the Teredo caused such devastations in the dykes which guard a great part of Holland against the encroachments of an overwhelming ocean that the Dutch began to tremble for their safety; and thus a miserable worm struck terror in the hearts of a nation which had laughed to scorn the tyranny of Philip II., and bid defiance to the legions of Louis XIV.



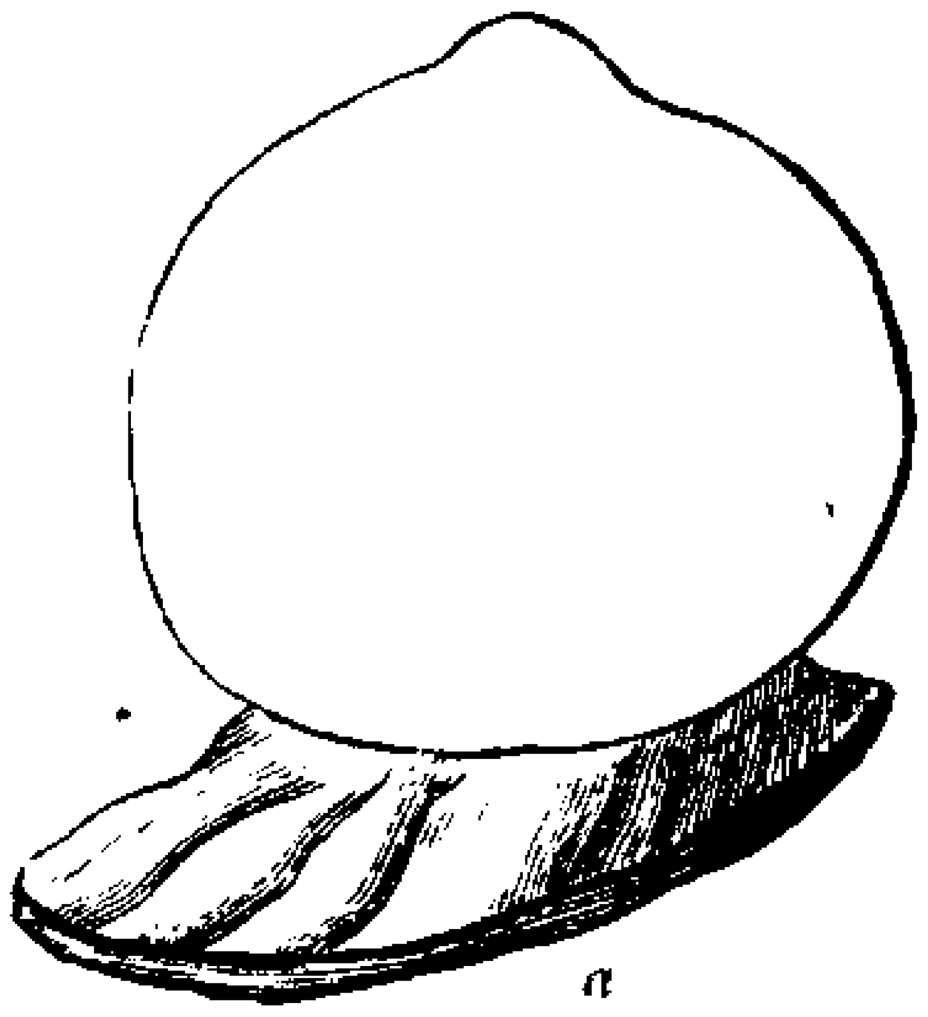
Pholas striata.



Shipworm.—(Teredo navalis.)

But while blaming the teredo for its damages, justice bids us not pass over in silence the services which it renders to man. If it here and there destroys useful constructions, on the other hand, it removes the wrecks that would otherwise obstruct the entrance of rivers and harbours; and we may ask whether these services do not outweigh the harm it causes. The pholades also belong to the noxious animals; they perforate the walls and calcareous jetties which man opposes to the fury of the sea, or raises for the creation of artificial harbours and landing places, destroy their foundations, and gradually cause their destruction.

The foot of the lamellibranchiates presents a great variety of form, and is found in various degrees of development, gradually passing into a rudimentary state, until finally it is completely wanting in the oyster family. In most of those which live at large it is strong and muscular, serving either as an excellent spade for speedy concealment in the sand when an

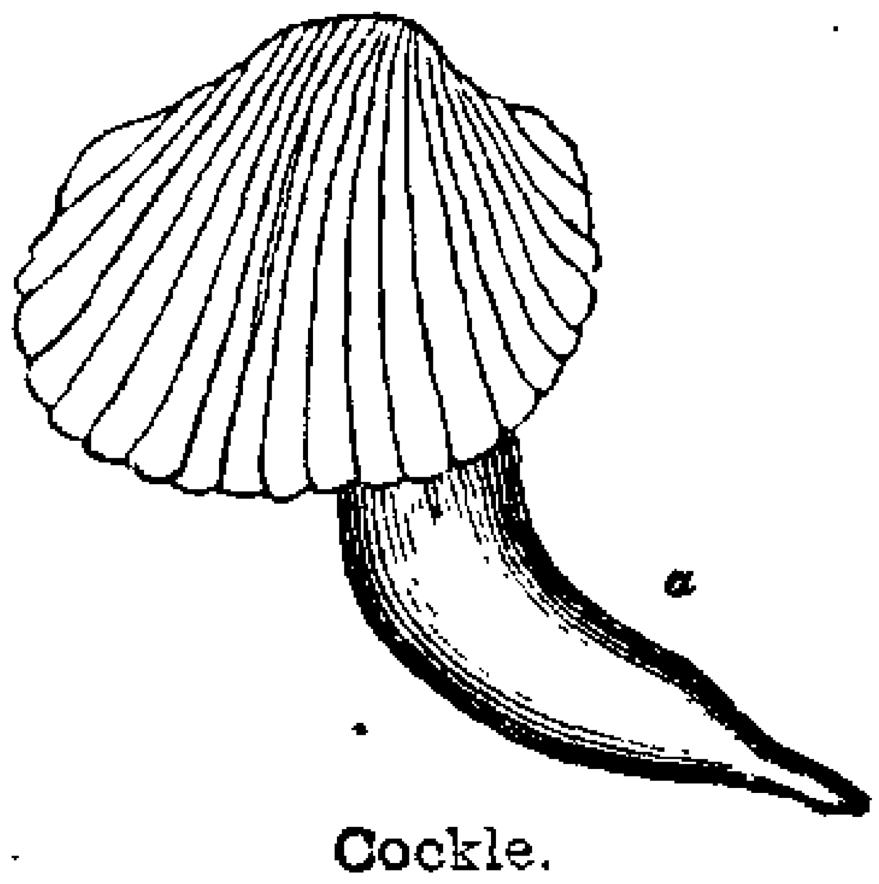


Petunculus.
a. Foot.

enemy approaches, or to dig a furrow into which the animal forces itself partially, and then advances slowly by making slight see-saw or balancing motions, or even to jump along with tolerable rapidity. Thus, the common Cockle protrudes its foot to its utmost length, bending it and fixing it strongly against the surface on which it stands; then by a sudden muscular spring it throws itself into the air, and, by repeating the process again and again, hops along at a pace one would hardly expect to meet with in a shell-bound mollusc.

Even some of those which have but a very rudimentary foot, incapable of subserving locomotion, are able to move from place to place by the sudden opening or shutting of their valves. In this manner the scallop, which inhabits deep places, where it lies on a rocky or shelly bottom, swims or flies through the water with great rapidity, and the file or rasp mussel, a closely related genus, principally occurring in the Indian Ocean, glides so swiftly through the water that the French naturalists Quoy and Gaimard were hardly able to overtake it.

In the stone or wood-boring bivalves the functions of the foot with regard to locomotion are much more limited than in the Cockle, or Tellina, as they merely consist in moving the animal up and down in the cavity where it has fixed its residence. In the Razor-Shells, which will sometimes burrow to the depth of two feet, and very rarely quit their holes, the cylindrical foot, no longer fit for horizontal locomotion, serves the animal for rising or sinking in the sand, for when about to bore, it attenuates it into a point, and afterwards contracts it into a rounded form so as to fix it by its enlargement when it desires to rise.

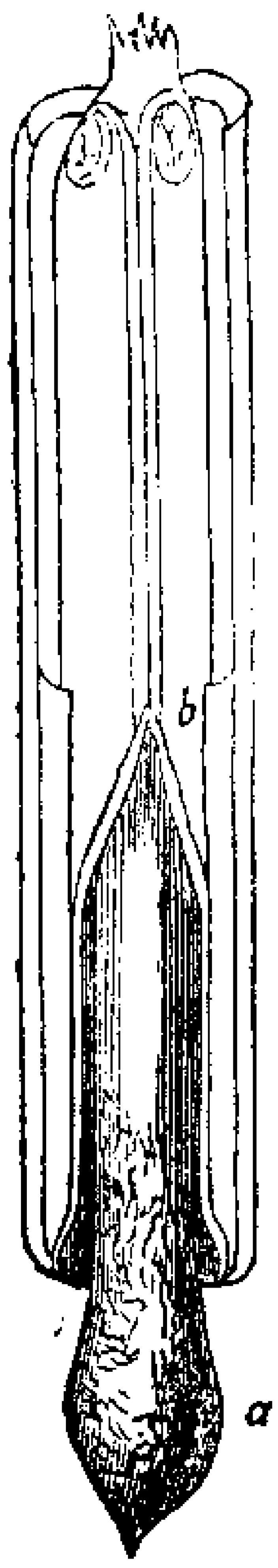


Cockle.
a. Foot.

In places where the razor-shells abound, they are sought after as bait for fish, and taken in spite of their mole-like facility of concealment, for when the tide is low, their retreat is easily recognised by the little jet of water they eject when alarmed by the motion of the fishermen above. Having thus detected their burrow, the wily enemy who is well aware that, though inhabiting the salt water, the Solen does not like too much of a good thing, merely throws some salt into the hole,

which, sadly irritating the nerves of the poor creature, generally brings it to the surface. He must, however, be very quick in grasping it firmly, for should he fail, the animal speedily sinks again into the sand and will remain there, being either insensible to the additional irritation or its instinct of self-preservation teaching it to remain beneath.

The pholades, which have very delicate milk-white valves, burrow holes in limestone or sandstone rocks, though occasionally they content themselves with houses of clay or turf. How creatures invested with shells as thin as paper and as brittle as glass are able to work their way through hard stone has long been a puzzle to naturalists, some of whom asserted that they attained their object by means of an acid solvent, others that they bored like an auger by revolving; but recent investigations have discovered that their short and truncated foot is the chief instrument they use in their mining operations, being provided at its base with a rough layer of sharp crystals of flint, which, when worn off, are soon replaced by others, and act as excellent files.



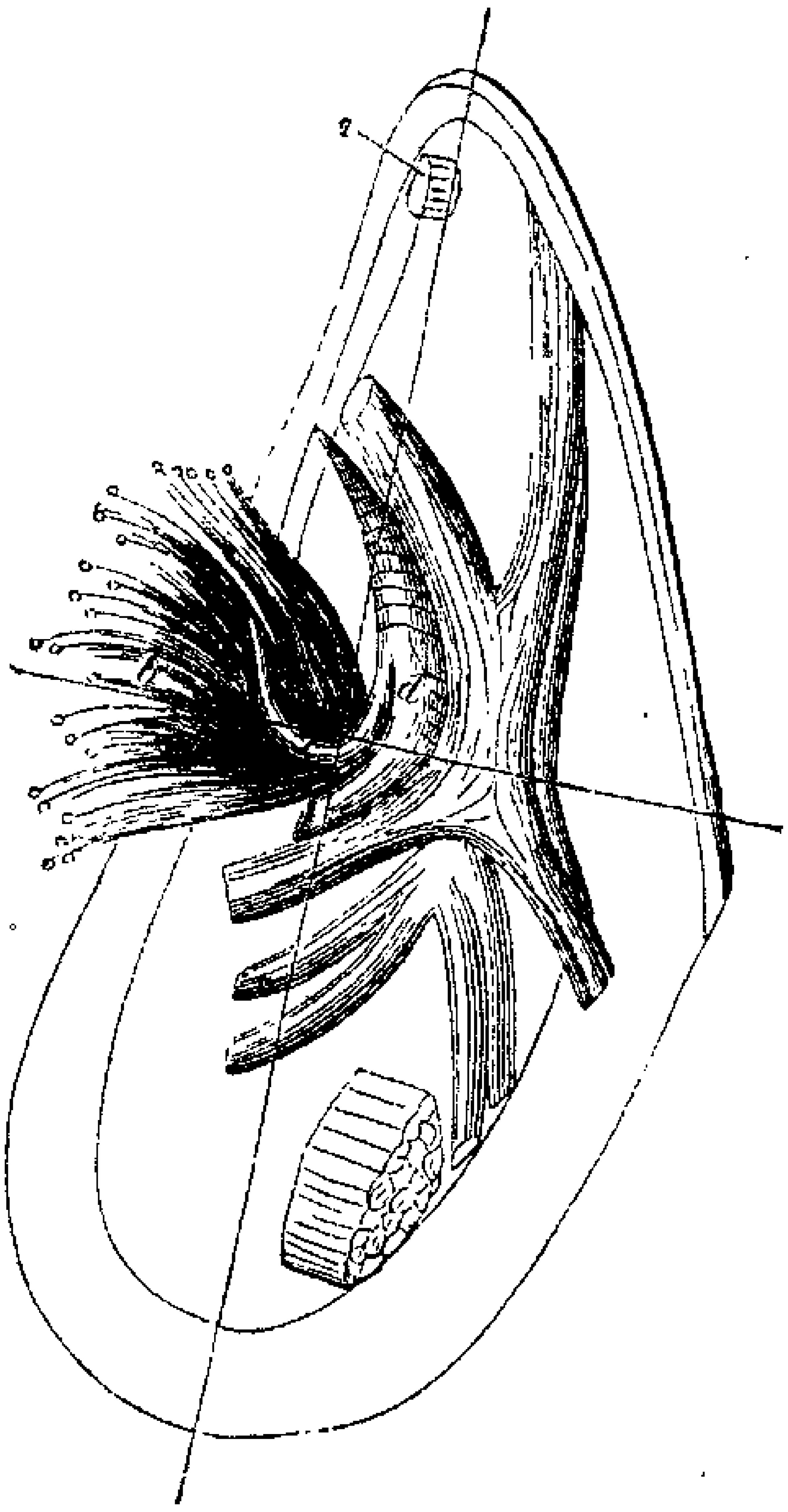
Solen, or Razor-Shell.
a. Foot.

In several of the sedentary genera the rudimentary foot, though incapable of locomotion, makes itself useful by spinning a bundle of silken threads, called *byssus*, or beard, which serve to anchor the animal to any solid submarine object as firmly as a ship in harbour. Generally the connection is permanent, but some species, among others the edible mussel, are able to detach the filaments from the glandular pedicle situated at the inferior base of the foot which originally secreted them, and then to seek another point of attachment.

If the byssus be examined under a powerful lens, before any of the filaments are torn, it is easy to perceive that these are fixed to submarine bodies by means of a small disc-like expansion of their extremities of various extent, according to the genus and species. Certain genera are celebrated for the abundance and fineness of their byssus; that of the Pinnæ, or Wing-Shells, among others, which are very common in some parts of the Mediterranean, and attain a considerable size, is so long and firm that in Naples it is sometimes manu-

factured into gloves and other articles of dress, though more as an object of curiosity than for use.

Thus we find in the same class of animals the same organ most variously modified in form and structure; now serving as a foot, now as a spade, or as a rasp, or as a spinning machine, and, throughout all these modifications, admirably adapted in every case to the mode of life of its possessor.



Pinna.
c. Pedicle from which the filaments are detached.
d. Inferior base of the foot.

The whole construction, and generally the extremely restricted locomotion, of the bivalves tells us at once that they are unable to attack their prey, but must be satisfied with the food which the sea-currents bring to the door of their shells, or within the vortex of their branchial siphons. But they have as little reason to complain as the equally slow or sessile polyps, bryozoa, and ascidians, for the waters of the ocean harbour such incalculable multitudes of microscopic animals and plants that their moderate appetite never remains long unsatisfied. The same streams which aërate their blood also convey to their mouth all the food which they require.

Deprived of more active weapons, most bivalves rely upon their shells as their best means of defence, and to answer this purpose, their stony covering must naturally increase in solidity the more its owner is exposed to injury. The pholades, lithodomes, and teredines, which scoop out their dwellings in stône or wood, and thus enjoy the protection of a retrenched camp, can do with a thin and brittle or even with a mere rudimentary shell. The solens, which at the least alarm bury themselves deeper and deeper in the sand, likewise require no closely-fitting valves; but the oysters or mussels, which have no external fortress to retire to, and are unable to move from the spot, would

be badly off indeed if they could not entirely conceal themselves within their thick shells, and keep them closed by strong muscular contraction.

Bernardin de St. Pierre, in his "Studies of Nature," points out another admirable provision for the safety of molluscs. Thus, those which crawl and travel, and can consequently choose their own asylums, are in general those of the richest colours. Such, among the Gasteropods, are the gaudily-tinted Nerites, and the polished marbled Cowries, the Olives, richly ornamented with three or four colours, and the Harps, which have tints as rich as the most beautiful tulips; while among the bivalves the vivacious Pectens, coloured scarlet and orange, and a host of other travelling shells, are impressed with the most lively colours. But those which do not swim, as the Oysters, which are adherent always to the same rocks, or those which are perpetually at anchor, as the Pinnas and Mussels, or those which repose on the bosom of Madrepores, such as the Arcs, or those which are entirely buried in the calcareous rocks, as the Lithodomi, or those which immovably, by reason of their weight, pave the surface of the reefs, as the Tridacna, are of the colour of the bottoms or floors which they respectively inhabit, in order, no doubt, that they shall be less perceived by their enemies.

But even so the best guarded of the bivalves fall a prey to innumerable enemies, and when we see the strand covered for miles and miles with their débris, we may rest assured that but few of the quondam inmates of these fragmentary shells have died a natural death. Annelides and Sea-snails, crustaceans and star-fishes, strand birds and even quadrupeds, all fatten upon their delicate flesh, and man devours incalculable numbers.

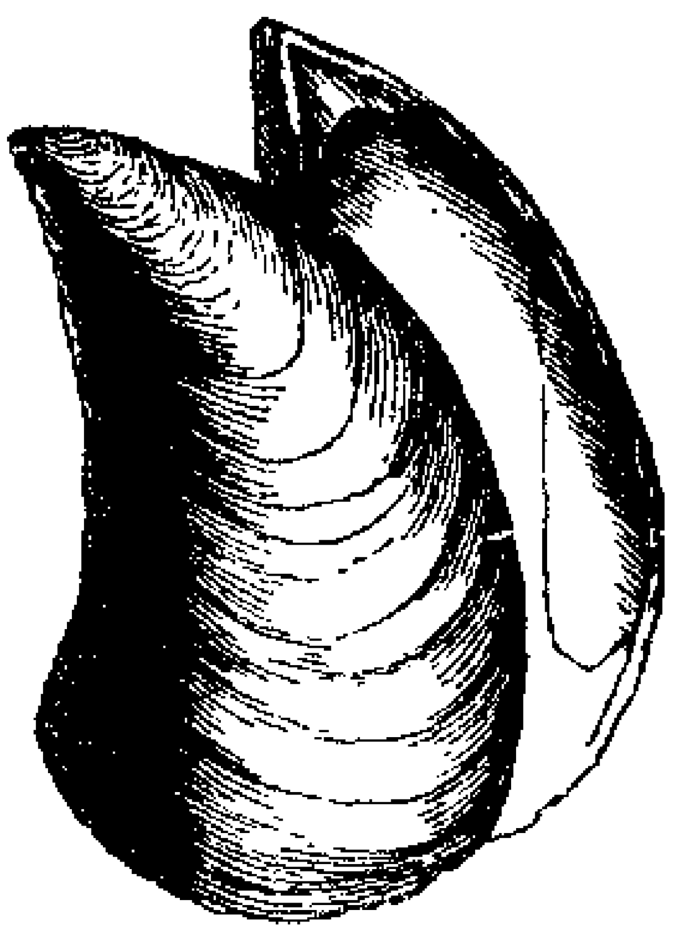
In vain the Pholas buries itself in stone, or the cockle in the sand; their security was at an end as soon as man had found out that they were grateful to the palate. The former was reckoned a delicacy by the ancients, and the latter is preferred by some to the oyster itself. So much is certain, that, during the years of famine caused by the potato disease, it preserved the lives of many of the poor Shetlanders and Orcadians.

Edible Cockle.

The Razor-Shells, particularly when roasted, and the Clam-Mussels, which are not only a favourite

repast of the Greenlander but also of the white bear and arctic fox, are equally reckoned among the most delicate of bivalves.

The common Mussel (*Mytilus edulis*), which is found in the littoral zone on almost every rocky shore, is eaten in vast numbers by the coast inhabitants, and carried in enormous masses into the interior of the country; it furnishes an equally cheap and agreeable food, but is not easy of digestion, and sometimes produces symptoms of poisoning, which have been ascribed to the eggs of asterias, on which it feeds during the summer. In the northern countries it is also in great request as a bait for cod, ling, rays, and other large fishes that are caught by the line. In the Frith of Forth alone from thirty to forty millions of mussels are used for this purpose, and in many places they are enclosed in *gardens*, the ground of which is covered with large stones, to which they attach themselves by their byssus or beard.



Edible Mussel.

It is a curious fact that the rearing of mussels should have been introduced into France as far back as the year 1235, by an Irishman of the name of Walton. This man, who had been shipwrecked in the Bay de l'Aiguillon, and gained a precarious living by catching sea-birds, observed that the mussels, which had attached themselves to the poles on which he spread his nets over the shallow waters, were far superior to those that naturally grow in the mud, and immediately made use of his discovery by founding the first "*bouchot*," or mussel-park, consisting of stakes and rudely interwoven branches. His example soon found imitators, and, strange to say, the method of construction adopted by Walton, six centuries ago, has been maintained unaltered to the present day. It may give some idea of the immense resources that might be obtained from so many utterly neglected lagunes when we hear that the fishermen of l'Aiguillon, although they sell three hundredweight of mussels for the very low sum of five francs, or four shillings, annually export or send them into the interior to the amount of a million or twelve hundred thousand francs.

The praise which Pliny bestowed on the oyster, calling it the palm or glory of the table, is still re-echoed by thousands of

enthusiastic admirers. We know that this king of the molluscs congregates in enormous banks, often extending for miles and miles, particularly on rocky ground, though it is also found on a sandy or even on a muddy bottom. Along the shallow alluvial shores of many tropical lands, great quantities of oysters are often found attached to the lower branches of the mangroves, where they are so situated as to be covered when the flood sets in, and to remain suspended in the air when it retires, swinging about as the wind agitates their movable support. The oyster inhabits all the European seas from the shores of the Mediterranean to the Westenfiord in Norway, where it finds its northern boundary, lat. 68° N., but the British waters may be considered as its headquarters, for nowhere is it found in greater abundance and of a richer flavour. After the ancient Romans had once tasted the oysters of Kent—the renowned *Rutupians*—they preferred them by far to those of the Lucrine lake, of Brindisi, and of Abydos, and Macrobius tells us that the Roman epicures in the fourth century never failed to have them at table. The "Pandores" of Edinburgh, and the "Carlingfords" of Dublin, are likewise celebrated for their delicious flavour; and if we turn to the Continent, we find the Bay of Biscay, and the coasts of Brittany and Normandy, of Holland and of Schleswig-Holstein, renowned for the excellence of their oysters.

Three sorts of oysters are distinguished in the trade. The first comprises those which are dredged from the deeper banks. These are the largest-sized, but also the least valued. The second consists of those that are gathered on a more elevated situation. Being accustomed to the daily vicissitudes of ebb and flood, they retain their water much longer, and can therefore be transported to much greater distances than the former. Those are preferred that grow on a clear bottom near the estuaries of rivers. The third and most valued sort of oysters are those that are cleaned and fattened in artificial *parks* or stews.

This branch of industry was already known to the Romans, and Pliny tells us that Sergius Orata, a knight, was the first who established an artificial basin for the cultivation of oysters, and realised large sums of money by this ingenious invention. At present Harwich, Colchester, Whitstable, and many other

seaports along our coast are famed for their oyster-stews, as are, in France and Belgium, Marennes, Havre, Dieppe, Tréport, and Ostend, where real British natives are cleaned and fattened for continental consumption.

The renowned oyster-parks of Ostend, the oldest of which celebrated its hundredth anniversary in 1866, are extensive walled basins, communicating by sluices with the open sea, so that the water can be let in and out with every returning tide. As microscopic algæ and animalculæ are produced in much greater numbers in these tranquil reservoirs than in the boisterous sea, the oysters find here much more abundant food, and being detached one from the other, they can also open and close their shells with greater facility, so that nothing hinders their growth. Thus fostered and improved by constant attention, they are greatly superior in flavour to the rough children of nature that are sent without any further preparation to market and condemned to the knife soon after having been dragged forth from their submarine abode. The highly prized *green* oysters owe their colour to the number of ulvæ, enteromorphæ, and microscopic infusoriæ, that are abundantly generated in the parks, and communicate their verdant tinge to the animal that swallows them.

In spite of their high price, which unfortunately debars the poorer classes from their enjoyment, the consumption of oysters is immense; so that in a commercial point of view they are by far the most important of all the mollusc tribes. Of the quantities eaten in London alone, it is impossible to give even an approximate guess, as no reliable statistics can be arrived at. Exclusive of those bred in Essex and Kent, in the rivers Crouch, Blackwater, and Colne, and in the channel of the Swale and the Medway, vast numbers are brought from Jersey, Poole, and other places along the coast. The Channel Islands alone, which export about 100,000 bushels a year, send a great part of their oysters to the metropolitan market.

The luxurious tables of Paris likewise consume unnumbered millions, and when we consider that, thanks to the railroad, even the most distant inland towns of the Continent may now be supplied with Ostend oysters, we cannot wonder that their price has risen enormously with the constantly increasing demand.

This great augmentation of value has naturally directed attention to the creation of new oyster-banks, and to the better management of those already existing, and fortunately the manner in which the mollusc propagates renders its culture in appropriate localities a by no means difficult task.

The oyster spawns from June to September. Instead of immediately abandoning its eggs to their fate, as is the case with so many sea-animals, it keeps them for a time in the folds of its mantle, between the branchial lamellæ, and it is only after having thus acquired a more perfect development that the microscopic larvæ, furnished with a swimming apparatus and eyes, emerge from the shell, and are then driven about by the floods and currents, until they find some solid body to which they attach themselves for life. In this manner the oyster produces in one single summer a couple of millions of young, which, however, mostly perish during the first wandering stage of their existence. Thus we see what rich rewards may be gained by protecting and fixing the oyster-larvæ at an early date; and that this can be done in many places without any great outlay of capital is proved to us by successful examples both in ancient and modern times.

Between the Lucrine Lake, the ruins of Cumæ, where of yore the Sibyl uttered her ambiguous oracles, and the promontory of Misenum, lies a small salt-water lake, about a league in circumference, generally from three to six feet deep, and reposing on a volcanic, black, and muddy bottom. This is the old Acheron of Virgil, the present Fusaro. Over its whole extent are spread from space to space great heaps of stones, that have been originally stocked with oysters brought from Tarentum. Round each of these artificial mounds stakes are driven into the ground, tolerably near each other, and projecting from the water, so as to be pulled up easily. Other stakes stand in long rows several feet apart, and are united by ropes, from which bundles of brushwood hang down into the water. All these arrangements are intended to fix the *oyster-dust*, that annually escapes from the parental shells, and to afford it a vast number of points to which it may attach itself. After two or three years the microscopic larvæ have grown into edible oysters. Then, at the proper season, the stakes and brushwood bundles are taken out of the water, and after the ripe berries of the marine vineyard

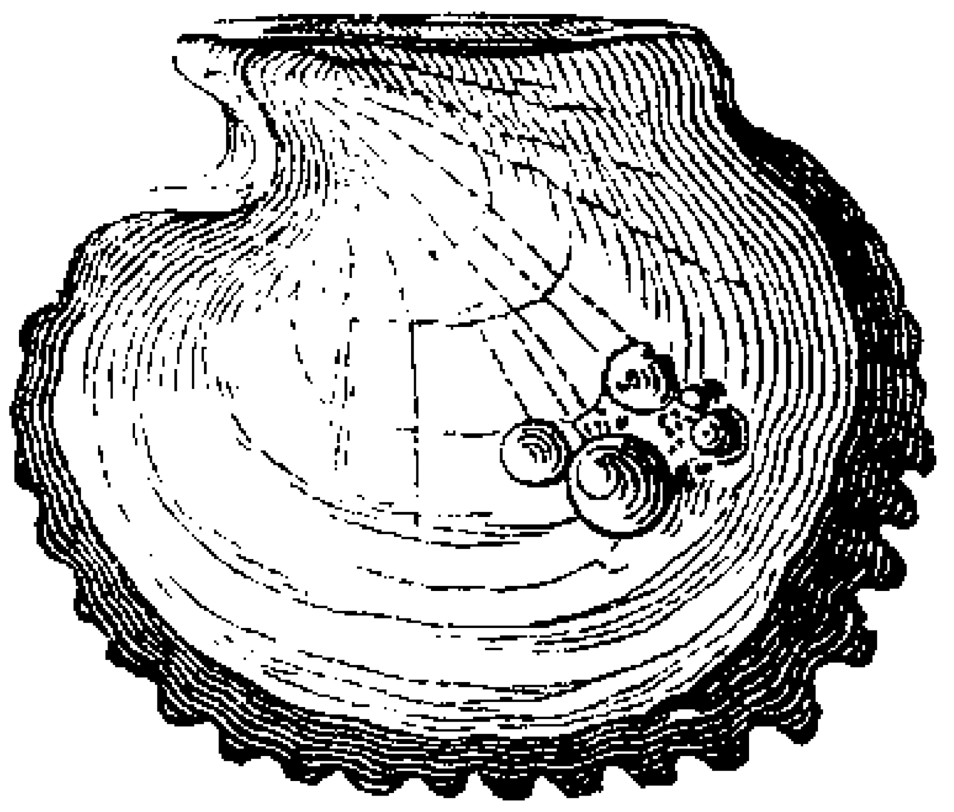
have been plucked, they are again immersed into the lake, until a new generation brings a new harvest. Thus the indolent Neapolitans have for ages given an example which has but recently been imitated by the men of the North. In 1858 a mason named Beef (a name which, if not misspelt, would seem to point out an English origin) inaugurated the modern era of oyster cultivation, at the island of Ré, near La Rochelle, by laying down a few bushels of growing oysters among a quantity of large stones on the fore shore. His success encouraged his neighbours to follow his example, so that now already upwards of 4,000 beds or *claires* extend along the coast.

Between March and May 1859 a quantity of oysters taken from different parts of the sea were distributed in ten longitudinal beds in the Bay of St. Brieux, on the coast of Brittany. The bottom was previously covered with old oyster-shells and boughs of trees arranged like fascines, which afford a capital holding-ground for the spat. In 1860 three of the fascines were taken up indiscriminately from one of the banks, and found to contain about 20,000 oysters each, of from one inch to two inches in diameter. The total expense for forming the above bank was 221 francs, and reckoning the number of oysters on each of the 300 fascines laid down on it at only 10,000, these sold at the low price of 20 francs a thousand would produce the sum of 60,000 francs, thus yielding a larger profit than any other known branch of industry.

Encouraged by these successful examples, an English company has obtained a grant by Act of Parliament of a piece of fore shore lying between the Whitstable and Faversham Oyster Companies' beds, and thus admirably situated for receiving a large quantity of floating spawn from these establishments. There can be no doubt that oyster cultivation will spread further and further, and that ultimately all the worthless bays and lagunes along our coasts will be converted into rich oyster-fields, yielding a good profit to their owners and enjoyment to millions of consumers.

A shell nearly related to the oyster produces the costly pearls of the East that have ever been as highly esteemed as the diamond itself. The most renowned pearl-fisheries are carried on at Bahrein, in the Persian Gulf, and in the Bay of Condatchy, in the island of Ceylon, on banks situated a few miles from

the coast. Before the beginning of the fishery, the government causes the banks to be explored, and then lets them to the highest bidder, very wisely allowing only a part of them to be fished every year. The fishing begins in February, and ceases by the beginning of April. The boats employed for this purpose assemble in the bay, set off at night at the firing of a signal-gun, and reach the banks after sunrise, where fishing goes on till noon, when the sea-breeze which arises about that time warns them to return to the bay. As soon as they appear within sight, another gun is fired, to inform the anxious owners of their return. Each boat carries twenty men and a chief; ten of them row and hoist up the divers, who are let down by fives,—and thus alternately diving and resting keep their strength to the end of their day's work. The diver, when he is about to plunge, compresses his nostrils tightly with a small piece of horn, which keeps the water out, and stuffs his ears with bees'-wax for the same purpose. He then seizes with the toes of his right foot a rope to which a stone is attached, to accelerate the descent, while the other foot grasps a bag of network. With his right hand he lays hold of another rope, and in this manner rapidly reaches the bottom. He then hangs the net round his neck, and with much dexterity and all possible despatch collects as many oysters as he can while he is able to remain under water, which is usually about two minutes. He then resumes his former position, makes a signal to those above by pulling the rope in his right hand, and is immediately by this means hauled up into the boat, leaving the stone to be pulled up afterwards by the rope attached to it. Accustomed from infancy to their work, these divers do not fear descending repeatedly to depths of fifty or sixty feet. They plunge more than fifty times in a morning, and collect each time about a hundred shells. Sometimes, however, the exertion is so great that, upon being brought into the boat, they discharge blood from their mouth, ears, and nostrils.


Ceylon Pearl-Oyster.

While the fishing goes on, a number of conjurors and priests

are assembled on the coast, busily employed in protecting the divers by their incantations against the voracity of the sharks. These are the great terror of the divers, but they have such confidence in the skill or power of their conjurors that they neglect every other means of defence. The divers are paid in money, or receive a part of the oyster-shells in payment. Often, indeed, they try to add to their gains by swallowing here or there a pearl, but the sly merchant knows how to find the stolen property. The oysters, when safely landed, are piled up on mats, in places fenced round for the purpose. As soon as the animals are dead, the pearls can easily be sought for and extracted from the gaping shells. After the harvest has been gathered, the largest, thickest, and finest shells, which furnish mother-of-pearl, are sorted, and the remaining heap is left to pollute the air. Some poor Indians, however, often remain for weeks on the spot, stirring the putrid mass in the hopes of gleaning some forgotten pearls from the heap of rottenness. The pearls are drilled and stringed in Ceylon, a work which is performed with admirable dexterity and quickness. For cleaning, rounding, and polishing them, a powder of ground pearls is made use of.

The Pacific also furnishes these costly ornaments to wealth and beauty, but the pearls of California and Tahiti are less prized than those of the Indian Ocean.

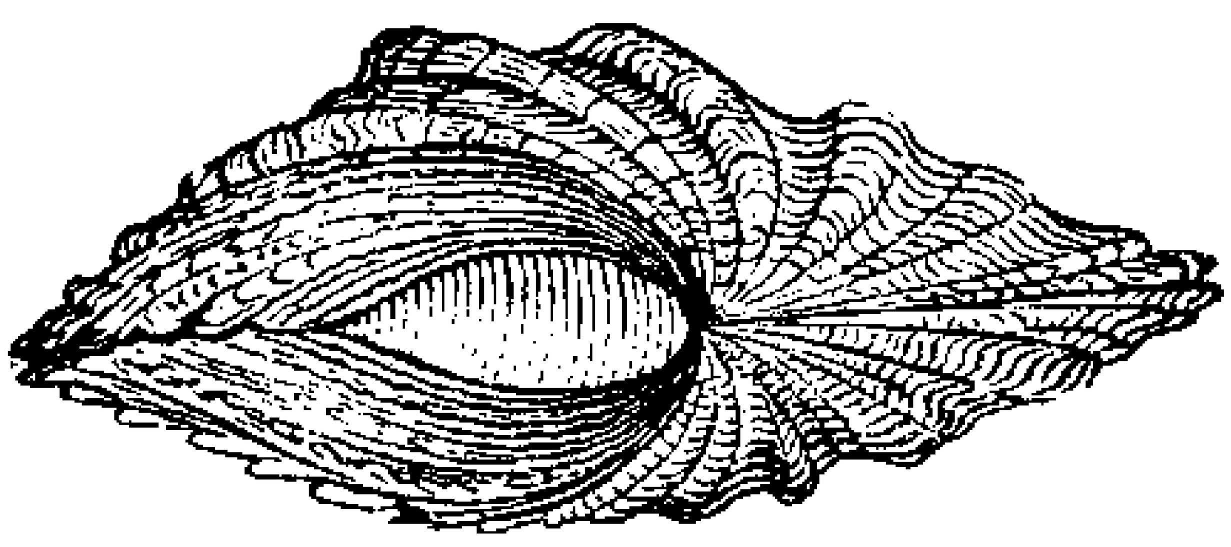
Pearl-like excrescences likewise form on the inner surface of our oysters and mussels, and originate in the same manner as the true pearls. The formation of the pearl, however, is not yet quite satisfactorily accounted for. Some naturalists believe that the animal accumulates the pearl-like substance to give the shell a greater thickness and solidity in the places where it has been perforated by some annelide or gasteropod; and according to Mr. Philippi, an intestinal worm stimulates the exudation of the pearl-like mass, which, on hardening, encloses and renders it harmless.

Brilliancy, size, and perfect regularity of form are the essential qualities of a beautiful pearl. Their union in a single specimen is rare, but it is of course still more difficult to find a number of pearls of equal size and beauty for a costly necklace or a princely tiara.

Nature has given the bivalves the same beauty of colouring

and wonderful variety of elegant or capricious forms as to the sea-snails; so that they are equally esteemed in the cabinets of wealthy amateurs. Among the most costly are reckoned the Spondyli, which are found in the tropical seas, where they grow attached to rocks. They are distinguished by the brilliancy of their colours, but particularly by the long thorny excrescences with which their shells are covered. A Parisian professor once pawned all his silver spoons and forks to make up the sum of six thousand francs which was asked for a *Royal Spondylus*; but on returning home was so *warmly* received by his lady that, overwhelmed by the hurricane, he flung himself on a chair, when the terrific cracking of the box containing his treasure reminded him too late that he had concealed it in his skirt-pocket. Fortunately but two of the thorns had been broken off, and the damage was susceptible of being repaired; his despair, however, was so great that his wife had not the heart to continue her reproaches, and in her turn began to soothe the unfortunate collector.

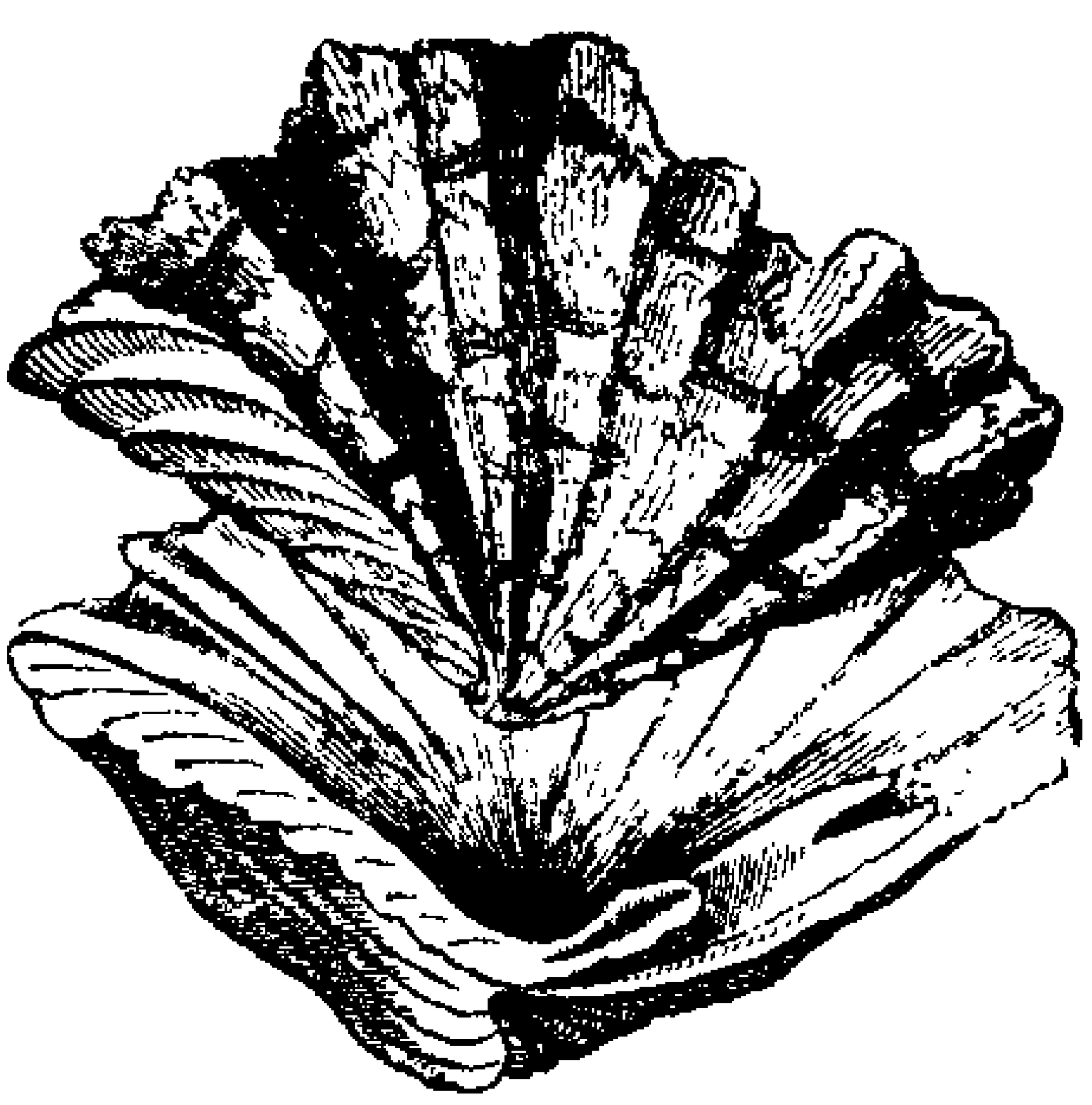
The gigantic Tridacna, which is now to be found in the shop of every dealer in shells, was formerly an object of such rarity



Tridacna gigas.

and value that the Republic of Venice once made a present of one of them to Francis I., who gave it to the Church of St. Sulpice in Paris, where it is still made use of as a basin for holy water. The tridacna attains a diameter of five feet, and a weight of five hundred pounds, the flesh alone weighing thirty. The muscular power is said to be so great as to be able to cut through a thick rope on closing the shell. It is found in the dead rocks on the coral reefs, where there are no growing lithophytes except small tufts. Generally only an inch or two in breadth of the ponderous shell is exposed to view, for the tridacna, like the pholas, has the power of sinking itself in the rock, by removing the lime about it. Without some means like this of security, its habitation would inevitably be destroyed by the roaring breakers. A tuft of byssus, however strong, would be a very imperfect security against the force of the sea for shells weighing from one to five hundred pounds. It

is found in the Indian Ocean and the Pacific as far as the coral zone extends. The animal of the tridacna, and of the nearly related Hippopus, distinguishes itself by the beauty of its colours. The mantle of the *Tridacna safranea*, for instance, has a dark blue edge with emerald-green spots, gradually passing into a light violet. When a large number of these beautiful creatures expand the velvet brilliancy of their costly robes in the transparent waters, no flower-bed on earth can equal them in splendour.

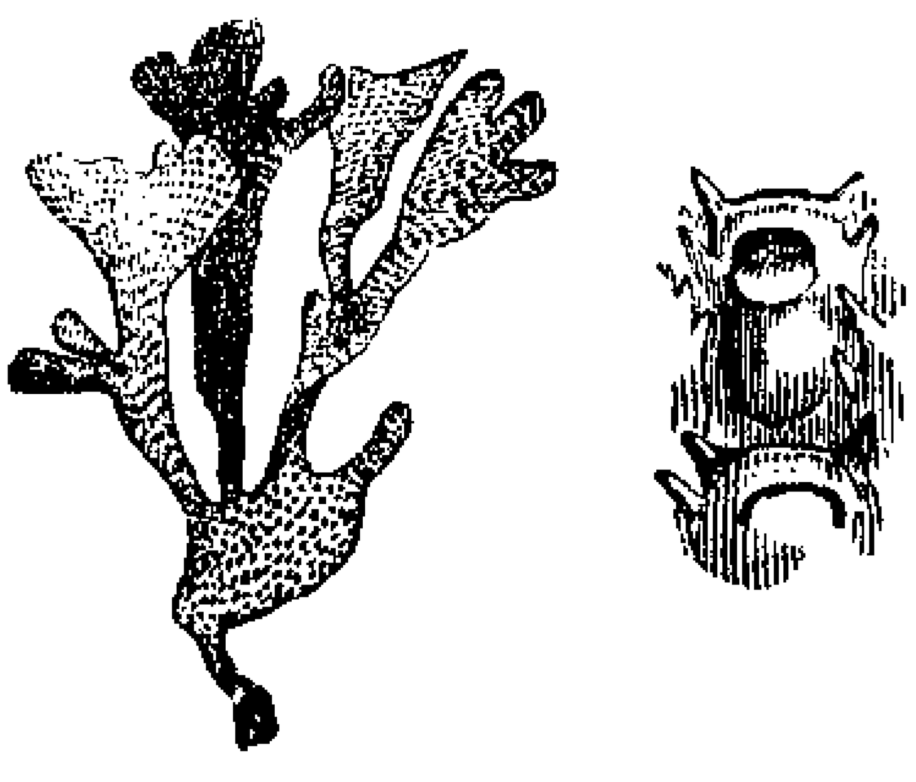


Hippopus maculatus.

Like the Lamellibranchiate Acephala, the Brachiopods are covered with a bivalve shell, but their internal organisation is very different. Instead of being disposed in separate gills, their respiratory system is combined with the ciliated mantle on which the vascular ramifications are distributed, but their most striking feature is the possession of spiral fringed arms or buccal appendages which serve to open the shell and occupy the greater part of its cavity. These curious organs are in some Brachiopods quite free, in others attached to a complicated cartilaginous or calcareous skeleton. None of the existing molluscs of this class are capable of changing place, but are either fixed to extraneous substances by the agglutination of one of their valves or by a muscular peduncle passing through a perforation of their shells. There are no more than forty-nine living species, chiefly belonging to the genera Terebratula and Crania, and generally found at great depths in the Southern Ocean; but the fossil remains of 1,370 species prove their importance in the primitive seas, where they rivalled the lamellibranchiates in numbers and variety. Though now so rare or so local in the British seas that ordinary collectors are not likely to meet with any, they abound in many of our oldest rocks. "A visit to the quarries at Dudley," says E. Forbes, "or an Irish lime-kiln, or an oolitic section on the Dorsetshire coast, or a green sand ravine in the Isle of Wight, will afford

more information about the Brachiopods than an examination of the finest collection of the living species. In each of the above excursions a different set of forms would be collected, for many of the palæozoic genera have altogether disappeared when we rise among the secondary rocks, and in the latter we find forms which closely remind us of existing species, but which, though very near, are yet unquestionably distinct. In formations of all epochs, a few generic types are common, and the Lingulæ of the earliest sedimentary formations, presenting traces of organic life, strikingly remind us of the species of that curious group living in exotic seas at the present day."

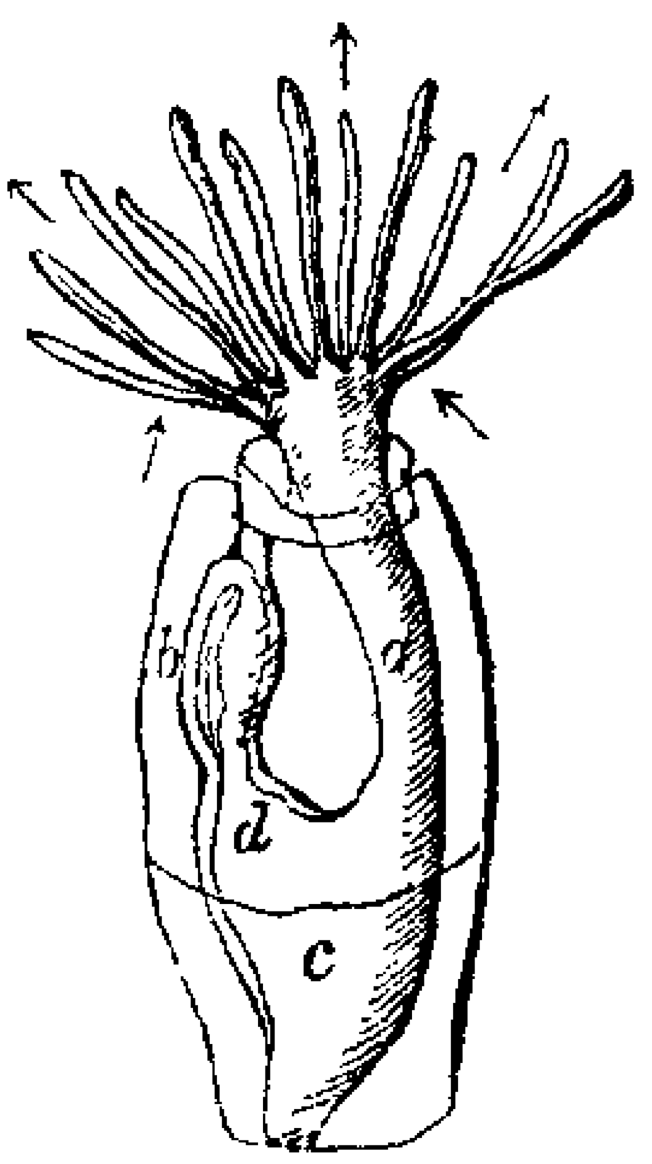
At the lower extremity of the great series of molluscous animals we find the Polyzoa (Bryozoa, or Sea-Mosses) and Tunicata. The former, which comprise the Sea-Mats (Flustræ, Escharæ), the Sea-Scurfs (Lepraliæ), the Retepores, the Cellulariæ, and several other families, were formerly reckoned among the polyps, whom they greatly resemble in appearance and mode of life, but far surpass by the complexity of their internal organisation. The Sea-Mats are among the commonest objects which the tide casts out upon our shores, for you will hardly ever walk upon the strand without finding their blanched skeletons among the relics of the retiring flood. Their flat leaf-like forms might easily cause them to be mistaken for dried sea-weeds, but a pocket-lens suffices to show that they are built up of innumerable little oblong cells, placed back to back like those of a honey-comb, and each crowned by four stout spines, which give their surface a peculiarly harsh feel when the finger is passed over it from the apex to the base. "The individual cells," says Mr. Gosse, "are shaped like a child's cradle, and if you will please to suppose some twenty thousand cradles stuck side to side in one plane, and then turned over, and twenty thousand more stuck on to these bottom to bottom, you will have an idea of the framework of a flustra. And do not think the number outrageous, for it is but an ordinary average. I count in an area of half an inch square sixty



Leaf-like Sea-Mat.

longitudinal rows, each of which contains about twenty-eight cells in that space; this gives 6,720 cells per square inch on each surface. Now a moderate-sized polyzoary contains an area of three square inches, i.e. six on both surfaces, which will give the high number of 40,320 cells on such a specimen. Many, however, are much larger."

Before the stormy tide detached them from the bottom of the sea, and left them to perish on the shore, each of the cells contained a living creature whose mouth was surrounded by a coronet of filiform and ciliated tentacles, destined to produce a vortex in the water, and thus to provide the tiny owner with its food. The body was bent on itself somewhat like the letter V, the one branch (*a*) being the mouth and throat, the other (*b*) the rectum, opening by an anus, and the middle part (*c*) the stomach. Each of these tiny members of the flustra colony possessed a considerable number of muscles; each was furnished with a movable lip or lid to block up the entrance of his cell when he courted retirement; each had his individual nerves, and consequently his individual sensations, though feeling and moving simultaneously with his fellow citizens by the agency of a system of nerves common to the whole republic, and sending forth a delicate filament to the inmate of each cell.



Flustra in its cell. (Highly magnified.)

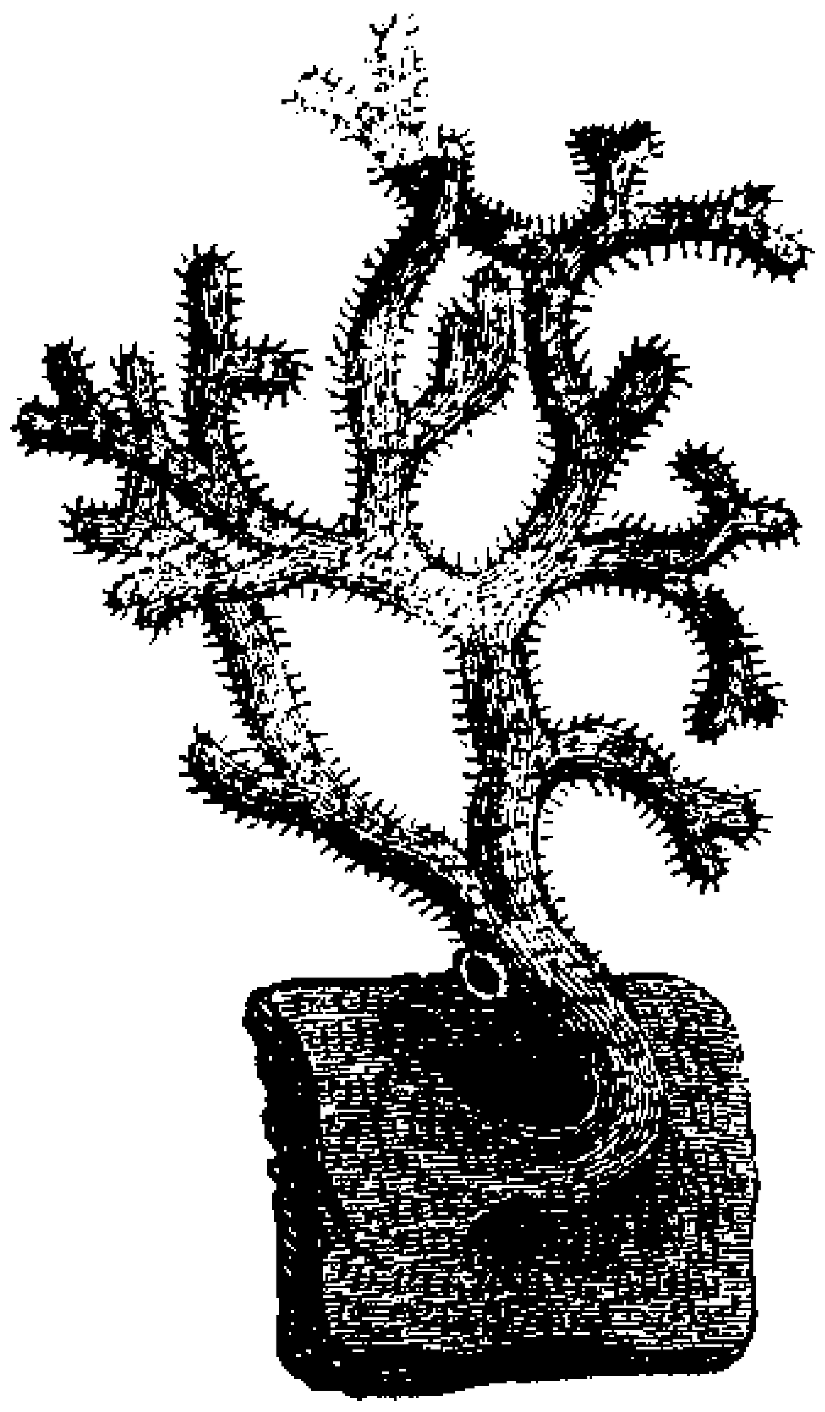
Such are the wonders which but for the microscope would for ever have remained unknown to man.

The Escharæ greatly resemble the Flustræ, for here also the cells are disposed side by side upon the same plane, so as to form a broad leaf-like polyzoary, which, however, is not of a horny or coriaceous texture, as in the latter genus, but completely calcified, so as to present something of the massiveness of the stony corals. The annexed wood-cuts, showing us *Eschara cervicornis*, first A, in its natural size; then B, a few cells magnified twenty diameters, and ultimately C, a single individual so highly magnified as to reveal some of the details of its otherwise invisible structure, give us a good idea of the truly remarkable organisation of the Polyzoa.

In the Escharæ and Flustræ the cellular extension of the

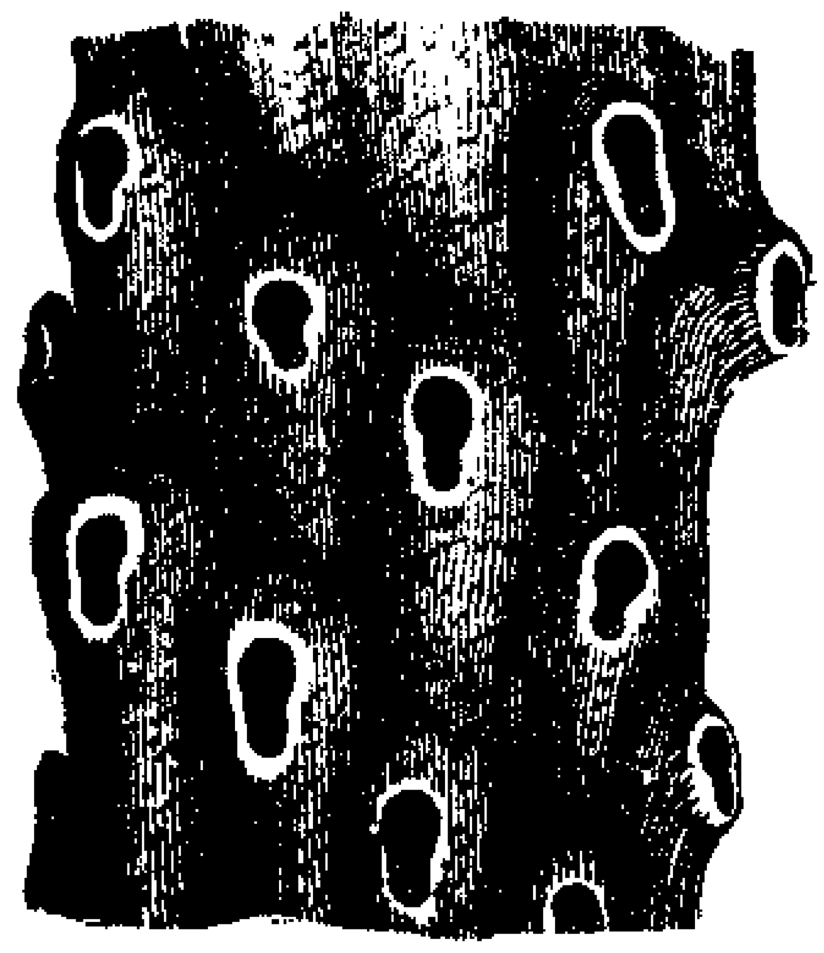
common stock or polyzoary is unbroken, and opening on both surfaces, while in the Retepores we find the cells opening only on one side, and the leaf-like expansion pierced like network.

A



Eschara cervicornis.
(Natural size.)

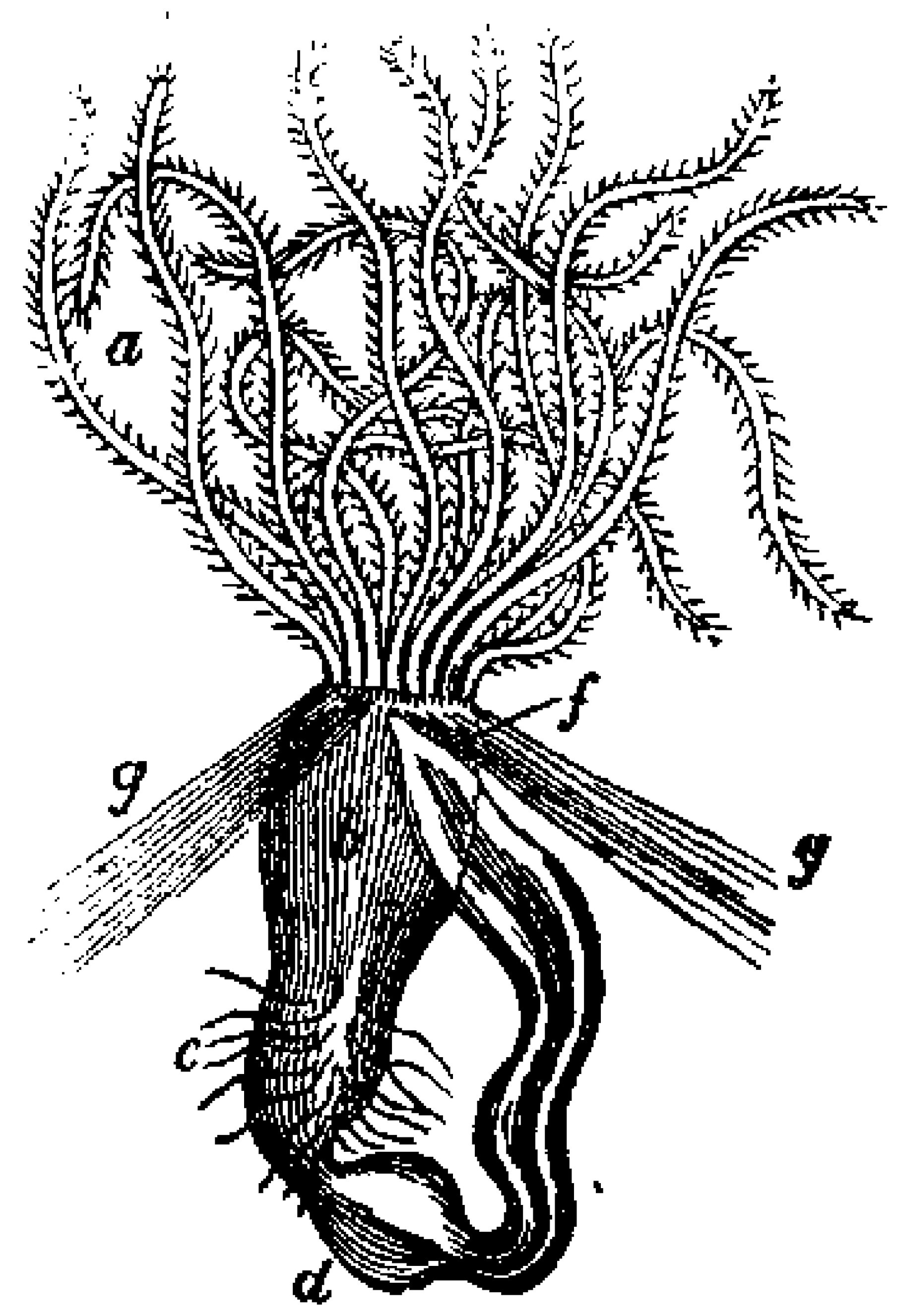
B



Portion of a branch of the polypary of Eschara cervicornis, magnified twenty diameters, to show the form and arrangement of cells.

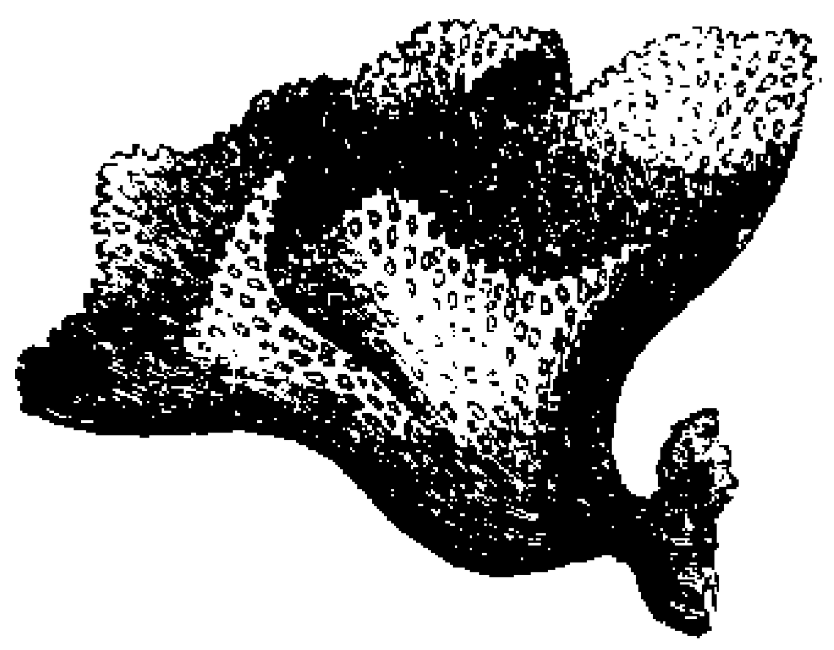
In cabinets of natural history, the species commonly called Neptune's ruffles will rarely be found wanting. It is a native of the Mediterranean, but individuals of a smaller size are also found in the British seas.

C



An individual of Eschara cervicornis, highly magnified.

a. Tentacula. *b.* First digestive cavity.
d. Stomach. *f.* Anus.



Retepora cellulosa.
(Neptune's Ruffle.)

The Lepraliæ, or Sea-Scurfs, form thin calcareous crusts of a white-yellow or reddish colour on rocks, shells, and sea-weeds. To the naked eye they appear as rude unsightly

eruptions, so as to justify their name derived from the hideous leprosy of the East, but, when magnified, their cells, generally disposed in regular concentric rows, exhibit a surprising diversity and elegance of structure. Forty species are found in the North Sea alone; hence we may judge how great the number of still unknown forms must be that spread their microscopic traceries over the algæ and shells of every zone.

It would lead me too far were I minutely to describe the Cellulariæ with their cells disposed in alternating rows on narrow bifurcated branches; the Tubulipores, with their mouths at the termination of tubular cells without any movable appendage or lip; the Bowerbankias and Lagunculas, with their creeping stems and separate cells; suffice it to say that a wonderful exuberance of fancy displays itself in the structure of the numerous varieties of the Polyzoa.

But a closer inspection reveals still greater miracles to the marine microscopist, for most genera, and chiefly the Cellulariæ, possess very remarkable appendages, or processes, presenting the most striking resemblance to the head of a bird. Each of these processes, or "aviculariæ," as they have been named, has two "mandibles," of which one is fixed like the upper jaw of a bird, the other movable like its lower jaw; the latter is opened and closed by two sets of muscles, which are seen in the interior of the head, and between them is a peculiar body, furnished with a pencil of bristles, which is probably a tactile organ, being brought forwards when the mouth is open, so that the bristles project beyond it, and being drawn back when the mandible closes. During the life of the

A. Portion of a Cellularia, magnified.
B. A Bird's Head Process, more highly magnified, and seen in the act of grasping another.

polyzoon, these tiny "vulture-heads," which are either sessile or pedunculated, keep up a continual motion, and it is most amusing to see them see-sawing and snapping and opening their jaws, and then sometimes in their incessant activity even closing upon the beaks of their neighbours.

It is still very doubtful what is their precise function in the economy of the animal; whether it is to retain within reach of the ciliary current bodies that may serve as food, or whether it is like the pedicellariæ of the sea-urchins to remove extraneous particles that may be in contact with the surface of the polyzoary. The latter would seem to be the function of the "vibracula," which are likewise pretty generally distributed among the polyzoa. Each of these long bristle-shaped organs, springing at its base out of a sort of cup, that contains muscles by which it is kept in almost constant motion, sweeps slowly and carefully over the surface of the polyzoary, and removes what might be injurious to the delicate inhabitants of the cells, when their tentacles are protruded. So carefully have these lowly molluscs been provided for!

The polyzoa can neither hear nor see, at least as far as we are able to ascertain, but the delicacy of their sense of touch is very great. "When left undisturbed in a glass of fresh sea-water," says Dr. Johnston,* "they push their tentacula beyond the mouth of the cell by straightening the body, and then expanding them in the form of a funnel or bell, they will often remain quiet and apparently immovable for a long time, presenting a very pretty and most interesting object to an observer of the 'minims of nature.' If, however, the water is agitated, they withdraw on the instant, probably by aid of the posterior ligament or muscle; the hinder part of the body is pushed aside up the cell, the whole is sunk deeper, and by this means the tentacula, gathered into a close column, are brought within the cell, the aperture of which is shut by the same series of actions. The polyzoa of the same polyzoary often protrude their thousand heads at the same time, or in quick but irregular succession, and retire simultaneously, or nearly so, but at other times I have often witnessed a few only to venture on the display of their glories, the rest remaining concealed, and if, when many are expanded, one is singled out and touched with a sharp in-

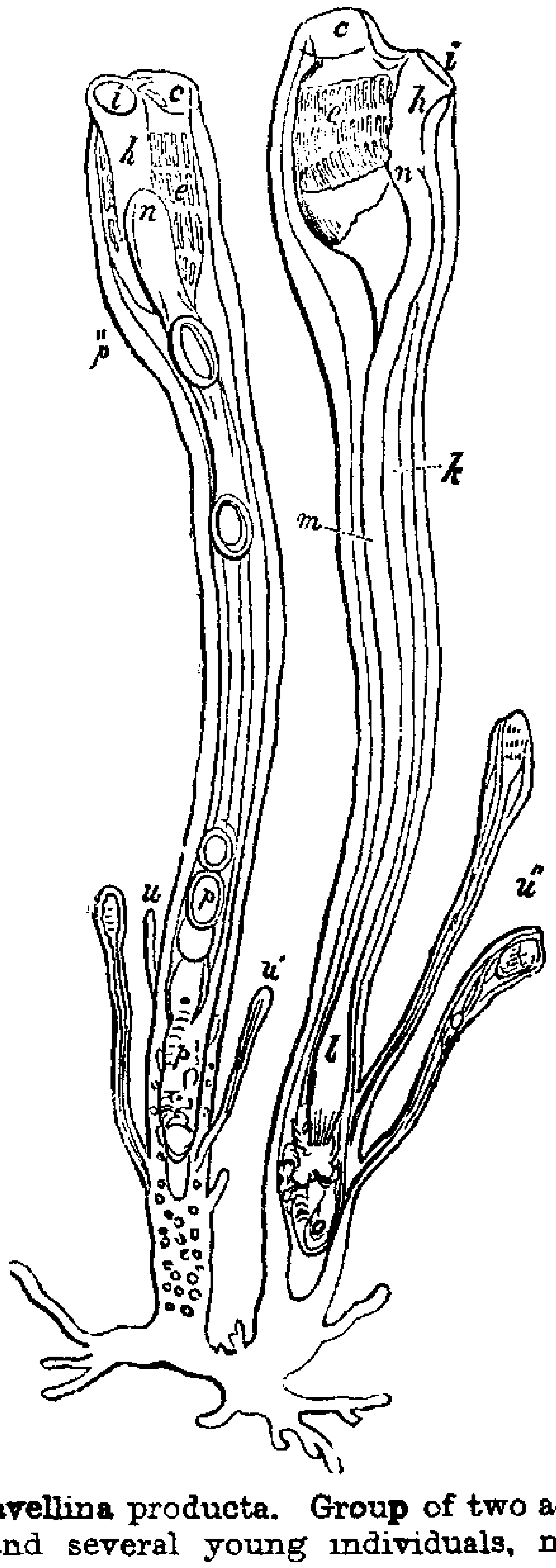
* "History of the British Zoophytes," 2nd edit. vol. i. p. 259.

strument, it alone feels the injury, and retires, without any others being conscious of the danger, or of the hurt inflicted on their mate. The polyzoa propagate by gemmation and by ova or eggs, which, germinating on the inner surface, escape at a later period into the visceral cavity, and are finally discharged into the wide sea, so to fulfil their mission in creation, and people the shores of every clime with myriads of busy workers in horn and in lime, which, with subtle chemistry, they draw from a fluid quarry and build up in textures of admirable beauty and heaven-ordered designs."

Each polyzoon begins with a single ovum. The original or seminal cell of a flustra or lepralia has no sooner fixed itself upon some stone, shell, or alga, than new buds begin to shoot forth, which in their turn produce others from their unattached margins, so as rapidly to augment the number of cells to a very large amount. Thus a common specimen of *Flustra carbasea* presents more than 18,000 individual polyzoa, and as each of these has about twenty-two tentacula, which are again furnished with about a hundred ciliæ a piece, the entire polyzoary presents no less than 396,000 tentacula and 39,600,000 ciliæ. The Rev. David Landsborough calculated that a specimen of *Flustra membranacea* five feet in length by eight inches in breadth had been the work and the habitation of above two millions of inmates, so that this single colony on a submarine island was about equal in number to the population of Scotland. As the tentacula are numerous in this species, four thousand millions of ciliæ must have provided for its wants, about four times the number of the inhabitants of this globe!

The Tunicata are so called because their soft parts are not enclosed in a calcified shell such as invests the majority of their class, but in a more or less coriaceous envelope or tunic which is either bag-shaped, and provided with two apertures, or tube-shaped, and open at the ends. They present a strong resemblance to the Polyzoa, not merely in their general plan of conformation, but also in their tendency to produce composite structures by gemmation; they may, however, be at once distinguished from them by the absence of the ciliated tentacula which form so conspicuous a feature in the external aspect of a flustra or a retepore. Their branchiæ, which have generally the form of ridges (*e*), occupy a large sac, forming, as it were,

the antechamber of the alimentary canal, which is barely distinguishable into gullet, stomach, and intestine, and always convoluted or folded once on itself. The Tunicata are exclusively marine, and widely spread from the arctic to the tropical seas. All of them are free during the earlier parts of their existence; some remain permanently so (Pyrosomidæ,



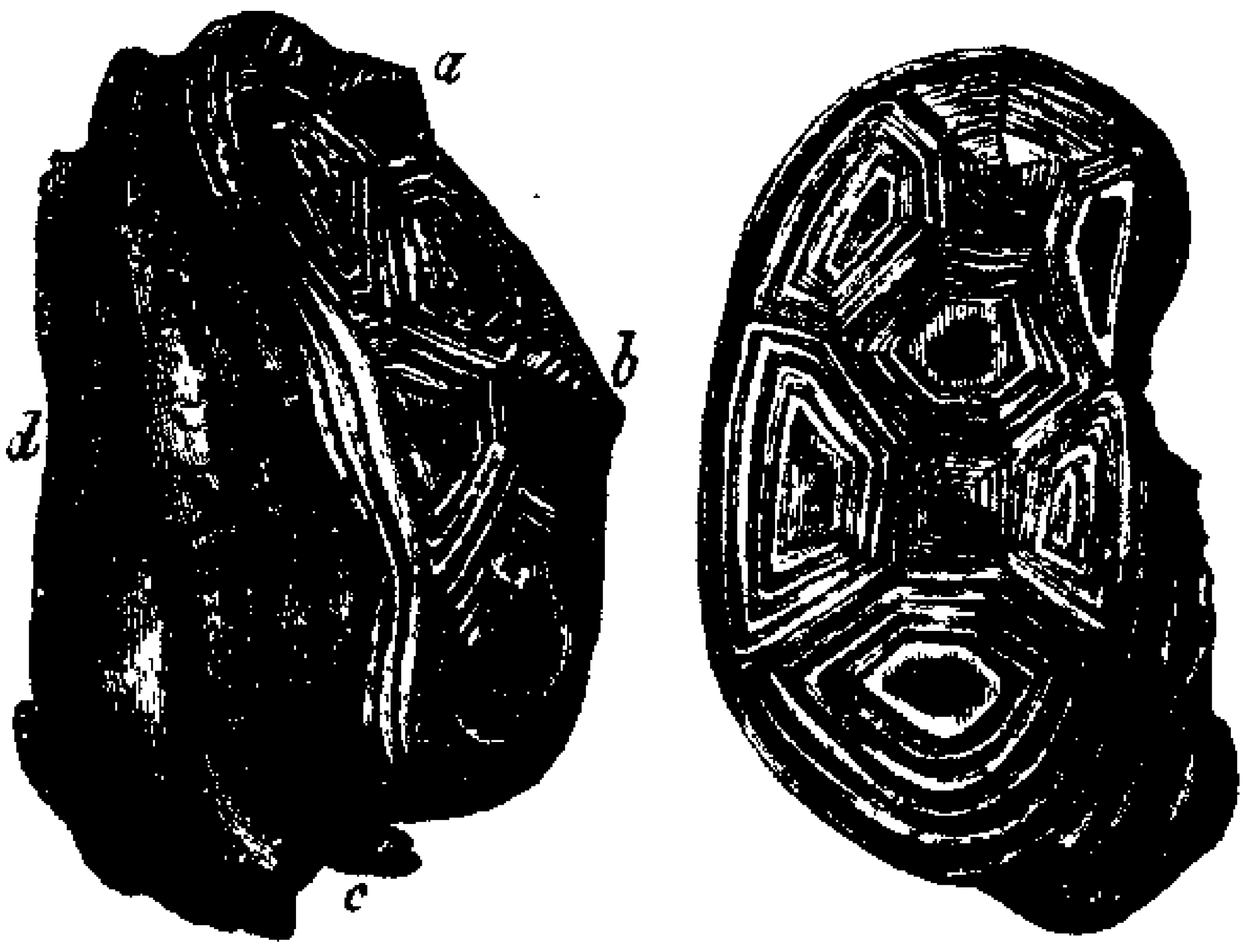
Clavellina producta. Group of two adult and several young individuals, magnified about five times.
c. Branchial orifice. *e.* Branchiæ. *i.* Anal orifice. *l.* Stomach. *o.* Heart. *u, u', u''.* Reproductive buds, springing from the abdomen of the adults.

Ascidia mammillata.
a. Branchial orifice, open.
b. Anal orifice, closed.

Salpæ), but the generality (Ascidiæ, Botrylli) become fixed to shells and other marine bodies; some exist as distinct individuals (Ascidiæ, Cynthia), whilst various degrees of combination are effected by others (Botryllus, Clavellina, Pyrosoma), and some are simple in one generation and combined in the next (Salpæ).

Thus the whole family is divisible into two groups, the *simple* and the *aggregate*; both branching out into numerous genera, of which my limits only allow me to mention some of the most remarkable. The simple Ascidiæ, or Sea-Squirts, are very common on our shores. "Rarely," says Forbes, "is the dredge drawn up from any sea-bed at all prolific in submarine creatures without containing few or many of their irregularly shaped leathery bodies, fixed to sea-weed, rock, or shell, by one extremity, or by one side, free at the other, and presenting two more or less prominent orifices, from which, on the slightest pressure, the sea-water is ejected with great force. On the sea-shore, when the tide is out, we find similar bodies attached to the under surface of rough stones. They are variously, often splendidly, coloured, but otherwise are unattractive or even repulsive in aspect. Some are of a large size, several inches in length. As may easily be imagined, they lead a very inactive life, except in the young state, when by means of a long tail they rapidly swim about, until finally settling in some convenient spot, they gradually assume the form and adopt the quiet life of the parent from which they sprang."

To the simple Tunicata belong also the Chelyosomata, whose coriaceous envelope, consisting of eight somewhat horny angular plates, reminds one of the carapace of the turtle. Their small and prominent orifices, perforating the plated surface, are each surrounded by six triangular valvules.



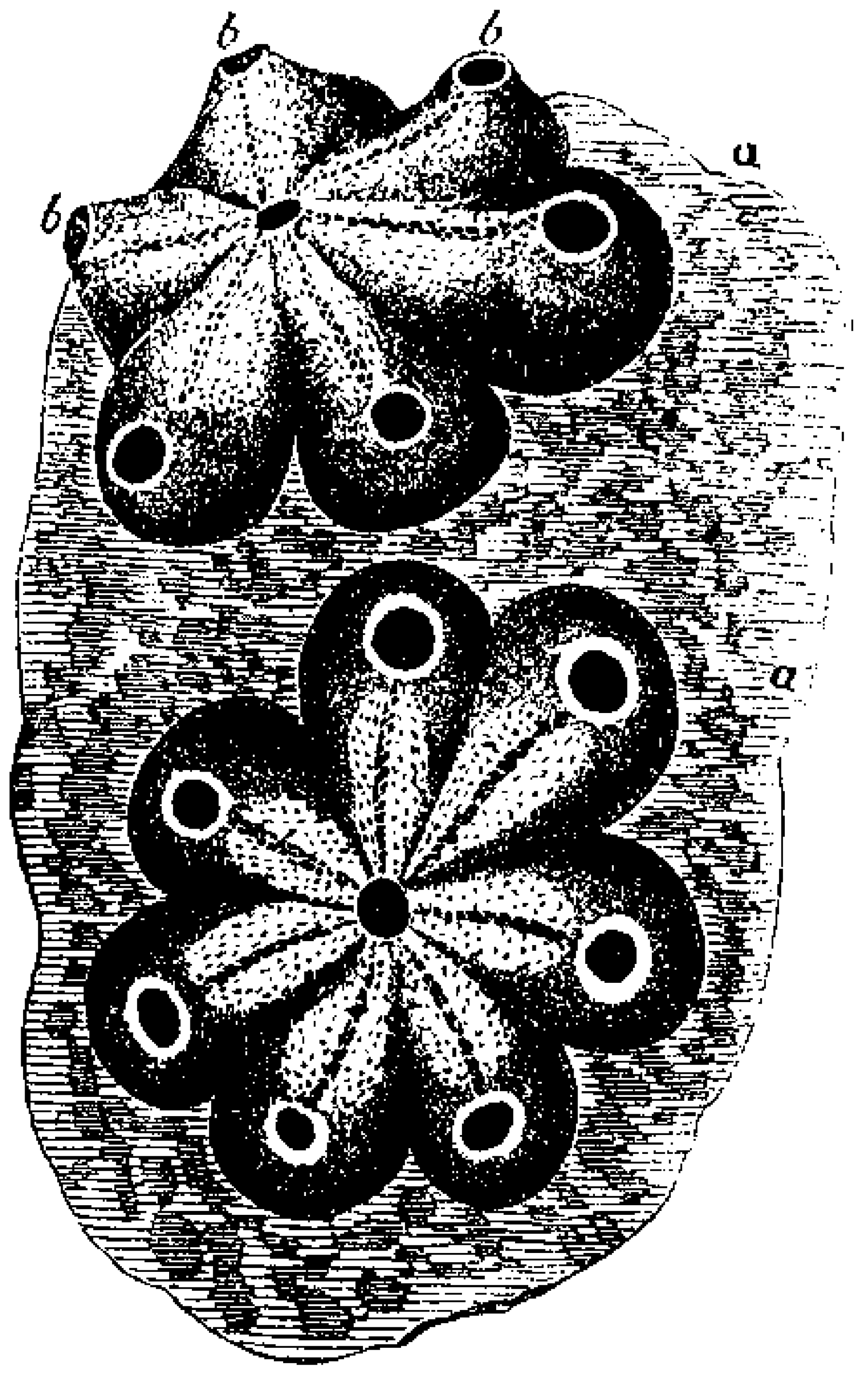
Chelyosoma Macleayanum.

a. Branchial orifice. *b*. Anal orifice.
c. Coriaceous envelope of the sides.
d. Stone to which the animal is fixed.

Some species of simple Ascidians on the coasts of the Channel and the Mediterranean are valued as articles of food. At Cette sea-squirts are taken regularly to market, and *Cynthia microcosmus*, although so repulsive externally, furnishes a very delicate morsel.

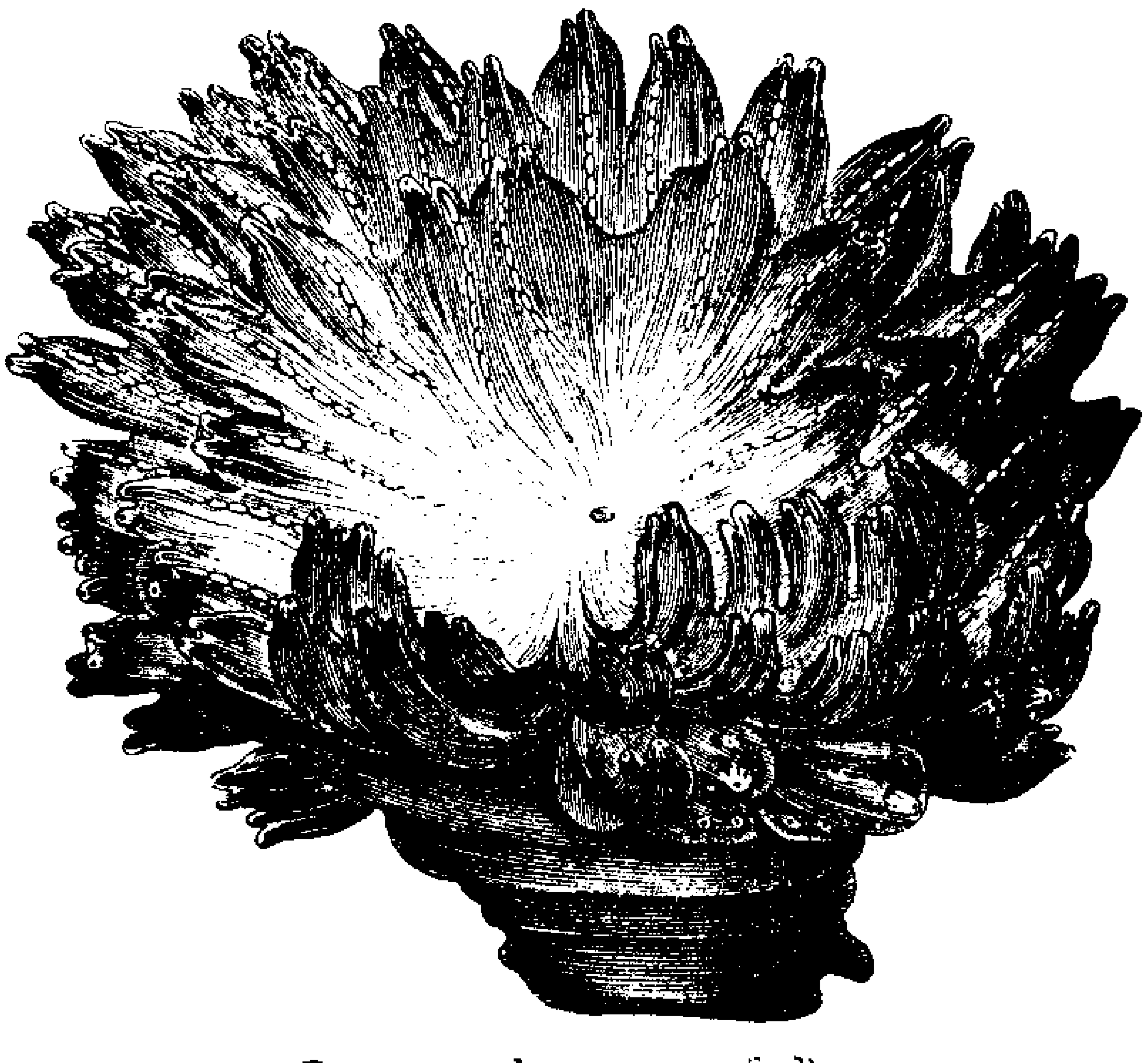
While in the Clavellinidæ the animals are connected by creeping tubular prolongations of the common tunic through

which the blood circulates, the Botrylli form translucent jelly-like masses of various hues of orange, yellow, purple, blue, grey, and green; sometimes nearly uniform in tint, sometimes beautifully variegated, and very frequently pencilled as if with stars of gorgeous device; now encrusting the surface of the rock, now descending from it in icicle-like projections. They are also frequently attached to the broad-leaved fuci, investing the stalks, or clothing with a glairy coat the expanse of the fronds. "In examining their bodies," says the distinguished naturalist previously quoted, "we find that it is not a single animal which is before us, but a commonwealth of beings bound together by common and vital ties. Each



Botryllus violaceus. Two of the stems magnified.

a. Common test.
b. Some of the branchial orifices.
c. The common anal orifice of one of the systems.

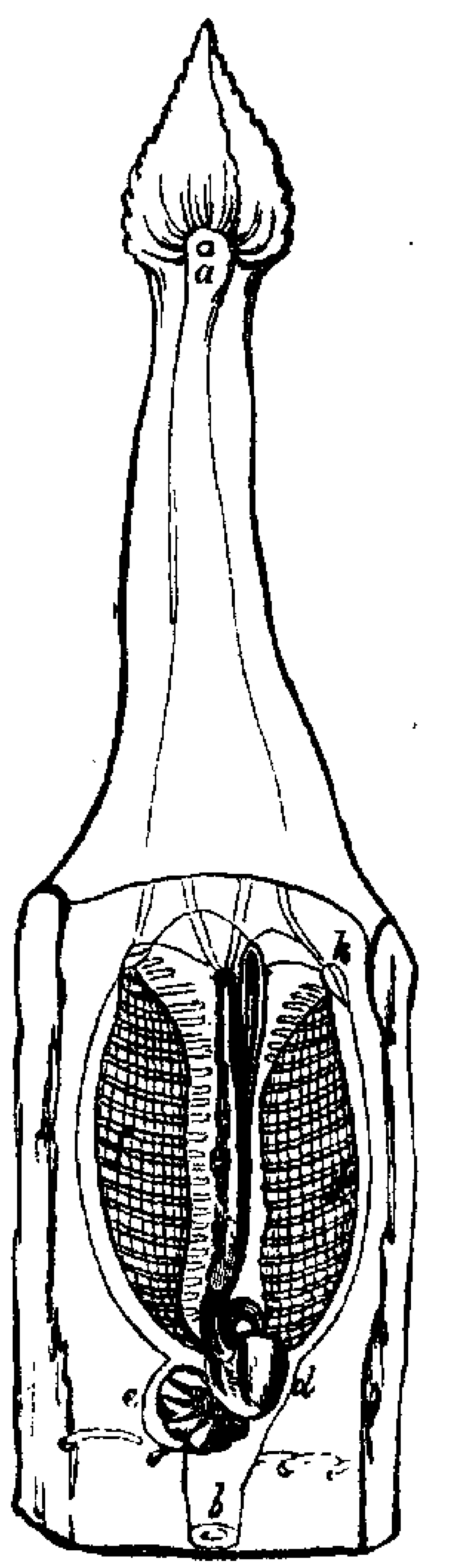


Diazona violacea (magnified).

star is a family, each group of stars a community. Individuals are linked together in systems, systems combined into masses.

Few bodies among the forms of animal life exhibit such exquisite figures as those which we see displayed in the combinations of these compound Ascidians."

In the genus Diazona, which has its chief seat in the Mediterranean, the animals, which are very prominent and arranged in concentric circles, form a single system expanded into a disc like that of a flower or of an Actinia. The anal orifices, it will be seen, are situated close to the branchial apertures at the free end of the single animals, while in the Botrylli they open into a central excretory cavity.



A single individual of Pyrosoma giganteum, cut out of the common test and magnified.

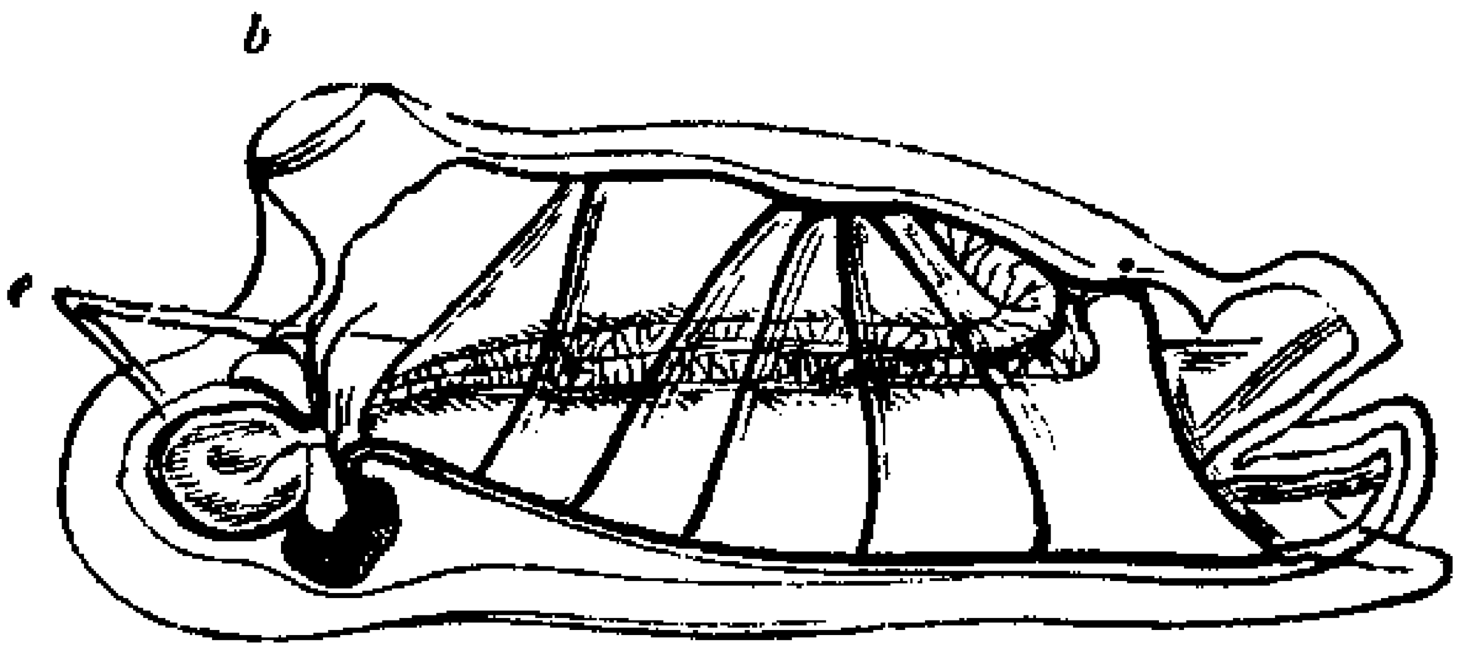
a. Branchial or external orifice.
b. Anal or internal orifice.
d. Stomach. *c.* Liver.
f. Branchiæ.

In the Pyrosomes we find large colonies of small individuals aggregated in the form of a cylinder open at one end. Their mouths or anterior extremities are situated on the exterior of this hollow body, which they bristle with large and longish tubercles (*a*), whilst the opposite or anal orifices (*b*) open into the cavity of the cylinder, whose smooth wall they perforate with numerous small holes. By a simultaneous action the central cavity is either narrowed or enlarged, and by this means the strange social republic glides slowly through the waters.

The Pyrosomes inhabit the Mediterranean and the warmer parts of the ocean. In the former at times their abundance is a source of great annoyance to the fishermen, sometimes even completely clogging their nets, and on the high seas they are not seldom met with in almost incredible profusion. Their delicate and transparent forms, their elegant tints, and their unrivalled phosphorescence render them objects of admiration to the voyager, and entitle them to rank amongst the most resplendent living gems of the ocean.

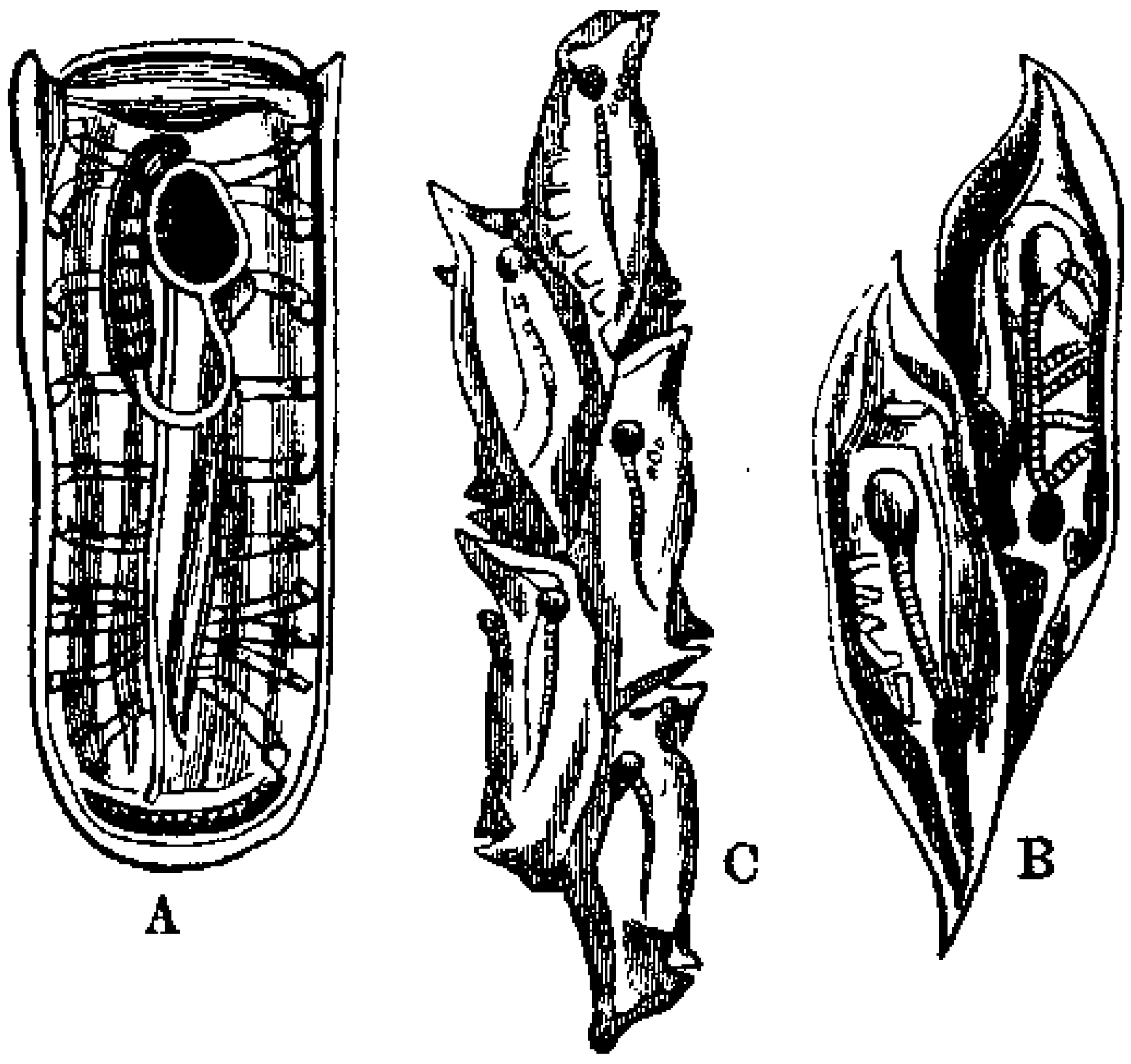
While the sessile Ascidiæ remind one of the polyps, the transparent Salpæ, freely swimming in the sea, bear a great resemblance to the pellucid jelly-fishes. Each resembles a

crystalline tube, through which one can distinctly see the internal coloured parts. Sometimes these animals, which abound in the



Salpa maxima.
a. Upper lip or posterior orifice. b. Anterior orifice. c. Prolongations of the test by which the animal is adherent to its neighbours.

warmer seas, are found solitary, at other times associated in circular or lengthened groups, termed garlands, ribands, and chains; but, strange to say, these two forms so different in outward

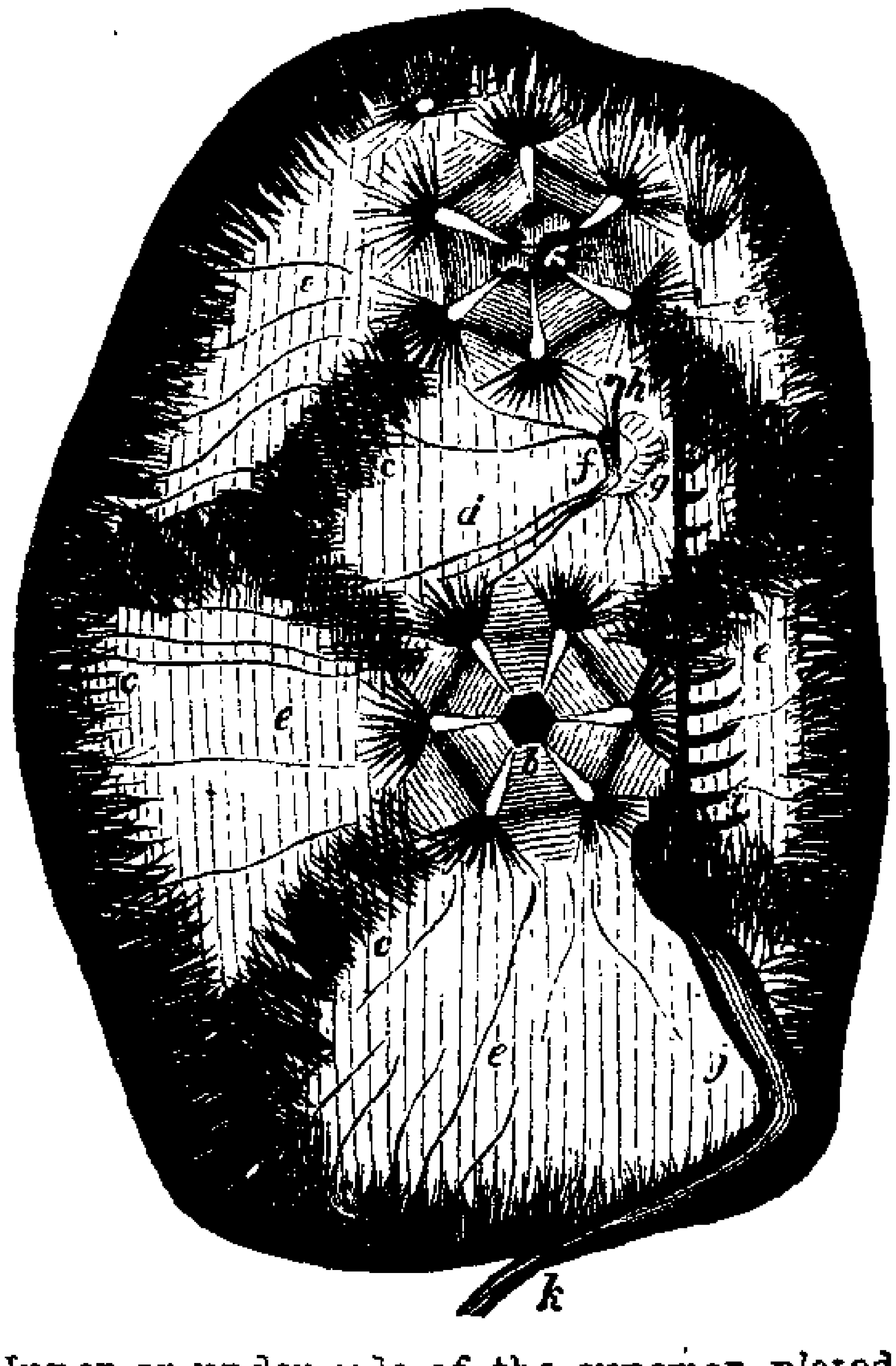


Salpæ, isolated and associated.
A. *Salpa runcinata*, solitary. B. *Salpa runcinata*, associated. C. *Salpa zonaria*, aggregated.

appearance are only the alternating generations of one and the same animal. The chained Salpæ produce only solitary ones, and the latter only chains, or, as Chamisso, to whom we owe the discovery of this interesting fact, expresses himself, "a salpa mother never resembles her daughter, or her own mother, but is always like her sister, her grand-daughter, or her grand-mother." When Chamisso first made known his discovery, he was laughed at as a fanciful visionary, but all later observations have not only fully confirmed his statement but also discovered similar or even more wonderful metamorphoses among the jelly-fish, polyps, crustacea, sea-urchins, and other marine animals. Thus Chamisso gave the first impulse to a whole series of highly interesting observations, and his rank is now as well established among naturalists as it has long been among the most distin-

guished poets of Germany. The Salpæ progress by the alternate contractions and dilatations of their tubular body. In this manner the chains, as if obeying a common impulse, glide along with a serpentine movement, and are often regarded by sailors as sea-snakes.

Before quitting the Tunicata, a few points of interest in their simple history remain to be noticed. Despite their humble organisation, they have a heart which, as may easily be ascertained in the transparent species, is subject to strange alternations of action. For after having received for a minute or two the blood *from* the branchiæ, and propelled it *to* the system at large, it will at once cease to pulsate for a moment or two, and then propel the blood *to* the branchial sac, receiving it at the same time *from* the system generally. After this reversed course has continued for some time, another pause occurs, and the first course is resumed. It is very probable that many of the Tunicata are able to hear and to see. In Chelyosoma, organs have been discovered whose structure seems to indicate that they are destined for the transmission of sound, and the Ascidiæ have frequently around the extremity of their tubes a row of coloured points similar to the imperfect organs of sight present in the majority of the bivalve Acephalans. Thus a closer examination of the lower animals is constantly bringing new faculties to light, and the further we penetrate into the secrets of their life the more we find occasion to admire the power and wisdom of their Maker!



Inner or under side of the superior plated surface of Chelyosoma Macleayanum.

a. Branchial orifice. *b.* Anal orifice.
c. Muscles bordering the carapace-plates.
d. Central hexagonal plate. *e.* Surrounding plates.
f. The nerve-ganglion and nerve-fibres.
g, h. Auditory apparatus.
i. Row of tentacles, anterior to the œsophagus.
j. Stomach. *k.* Part of the intestine.

CHAP. XVI.

ECHINODERMATA.

STAR-FISHES, SEA-URCHINS, AND SEA-CUCUMBERS.

The Star-Fishes —Their Feet or Suckers.—Voracity of the Asterias.—The Rosy Feather-Star.—Brittle and Sand-Stars.—The real Sea-Stars of the British Waters. —The Sea-Urchins.—The Pedicellariæ.—The Shell and the Dental Apparatus of the Sea-Urchin.—The Sea-Cucumbers—Their strange Dismemberments.—Trepang-fishing on the Coast of North Australia.—In the Feejee Islands.

"As there are stars in the sky, so are there stars in the sea," is the poetical exordium of Link's treatise on Star-fishes, the first ever published on the subject; and James Montgomery tells us in rather bombastic style, that the seas are strewn with the images of the constellations with which the heavens are thronged.

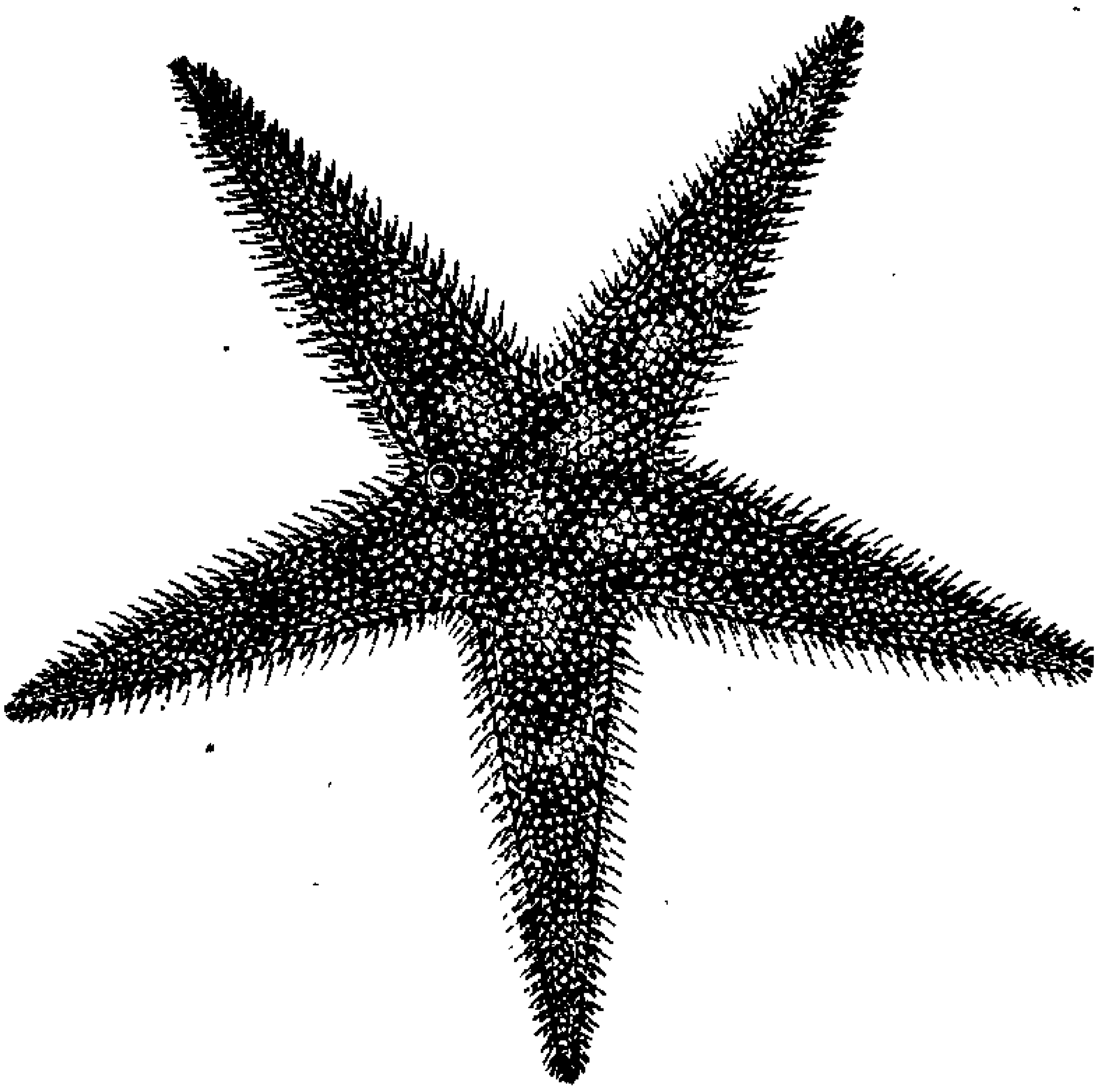
This is no doubt highly complimentary to the star-fishes, but is far from being merited by any particularly shining or radiant quality; as they occupy a very inferior grade among the denizens of the sea, and merely owe their stellar name to their form, which somewhat resembles the popular notion of a star.

But if they are of an inferior rank to most marine animals; if even the stupid oyster boasts of a heart, which they do not possess; yet a closer inspection of their organisation shows us many wonderful peculiarities, and proves to us once more that nature has impressed the stamp of perfection as well upon her lowest and most simple creations, as upon those beings that rank highest in the scale of life.

Every one knows the common Star-fish, with its lanceolate arms; its generally orange-coloured back, thickly set with tubercles, and the pale under-surface, with its rows of feet, feelers, or suckers, which serve both for locomotion and the seizure of food.

When one of these creatures is placed on its back, in a plate filled with sea-water, it is exceedingly curious to watch the activity which those numberless sucking feet display. At first

the star-fish is motionless; for, offended by the rough handling it has undergone, the feet have all shrunk into the body; but soon they are seen to emerge like so many little worms from



Star-Fish.

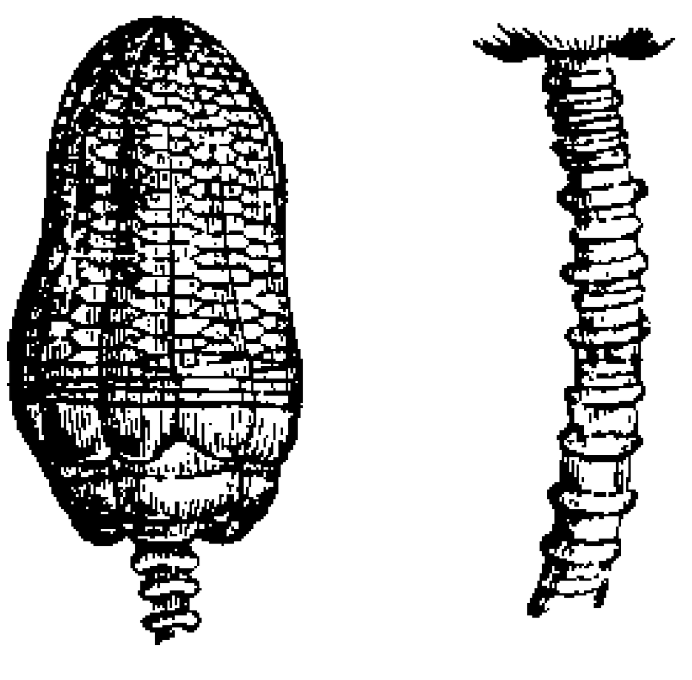
The upper tuberculated surface is shown, with some of the spines of the under surface projecting at the sides of the rays. At one of the angles between the rays, on the right side, is seen the eccentric calcareous plate, or madreporic tubercle, which indicates the existence of a bilateral symmetry.

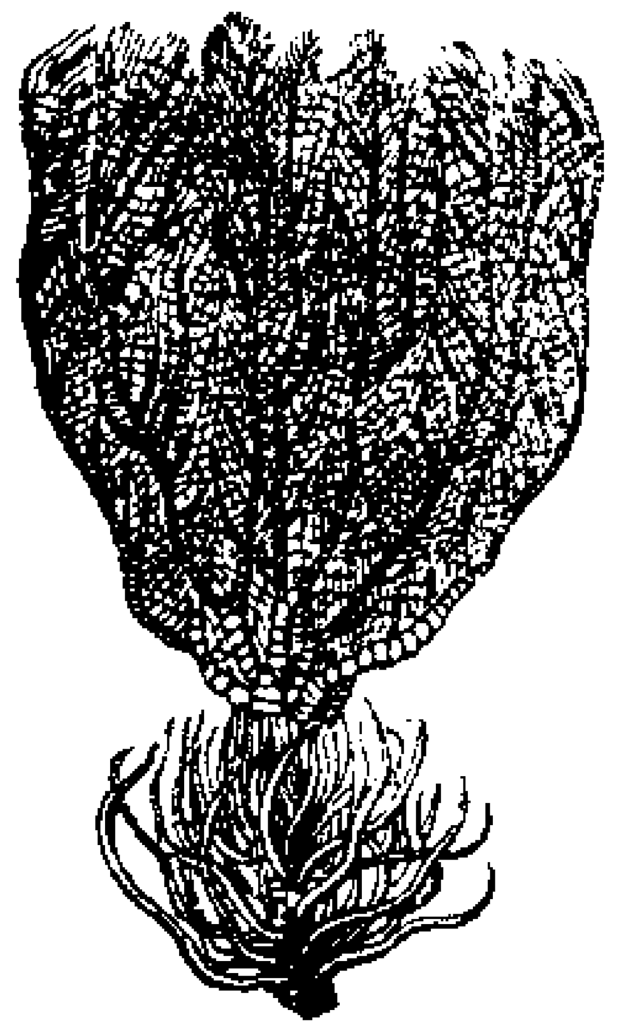
their holes, and to grope backwards and forwards through the water, evidently seeking the nearest ground to lay hold of. Those that reach it first immediately affix their suckers, and, by contracting, draw a portion of the body after them, so as to enable others to attach themselves, until, pulley being added to pulley, their united power is sufficient to restore the star-fish to its natural position.

This act of volition is surely remarkable enough in so simple an animal, which scarcely possesses the rudiments of a nervous system, but the simple mechanism by which the suckers are put into motion is still more wonderful. Each of these little organs is tubular, and connected with a globular vesicle filled with an aqueous fluid, and contained within the body of the star-fish immediately beneath the hole from which the sucker

issues. When the animal wishes to protrude its feet, each vesicle forcibly contracts, and, propelling the fluid into the corresponding sucker, causes its extension; and, when it desires to withdraw them, a contraction of the suckers drives back the fluid into the expanding vesicles. The internal walls of the suckers and their vessels are furnished with vibratory cilia, and by this simple means a continual circulation of the fluid they contain goes on within them.

Numerous species of star-fishes are so very common in our waters, that in many places the sea-bottom is literally paved with them. They likewise abounded in the primeval ocean, for deep beds of carboniferous limestone and vast strata of the triassic muschelkalk are often formed by the accumulation of little else than the skeletons of Encrinites and Pentacrinites, which, unlike the sea-stars which every storm drifts upon our shores, did not move about freely, but were affixed to a slender flexible stalk, composed of numerous calcareous joints connected together by a fleshy coat. The feathered bifurcated arms of the Crinoids are unprovided with suckers, which would have been perfectly useless to creatures not destined to pursue their game to any distance, but passively to receive the nutriment which the current of sea-water set in motion by their richly-ciliated pinnules conveys to the mouth. These beautiful creatures were formerly supposed to be nearly extinct, for up to within the last few years only two living stalked crinoids were known in the ocean of the present period, but the dredge has latterly brought up new and remarkably fine species from depths of more than 2000 fathoms, and there is every reason to believe that these animals still form an important element in the abyssal fauna.*


Lily-Encrinite.


Portion of the Pentacrinus Briareus. (Fossil.)

Of freely-swimming Crinoids but one single representative is known in the northern seas, the Rosy Feather-star (*Comatula rosacea*), whose long and delicately fringed rays and deep rose

* See page 420.

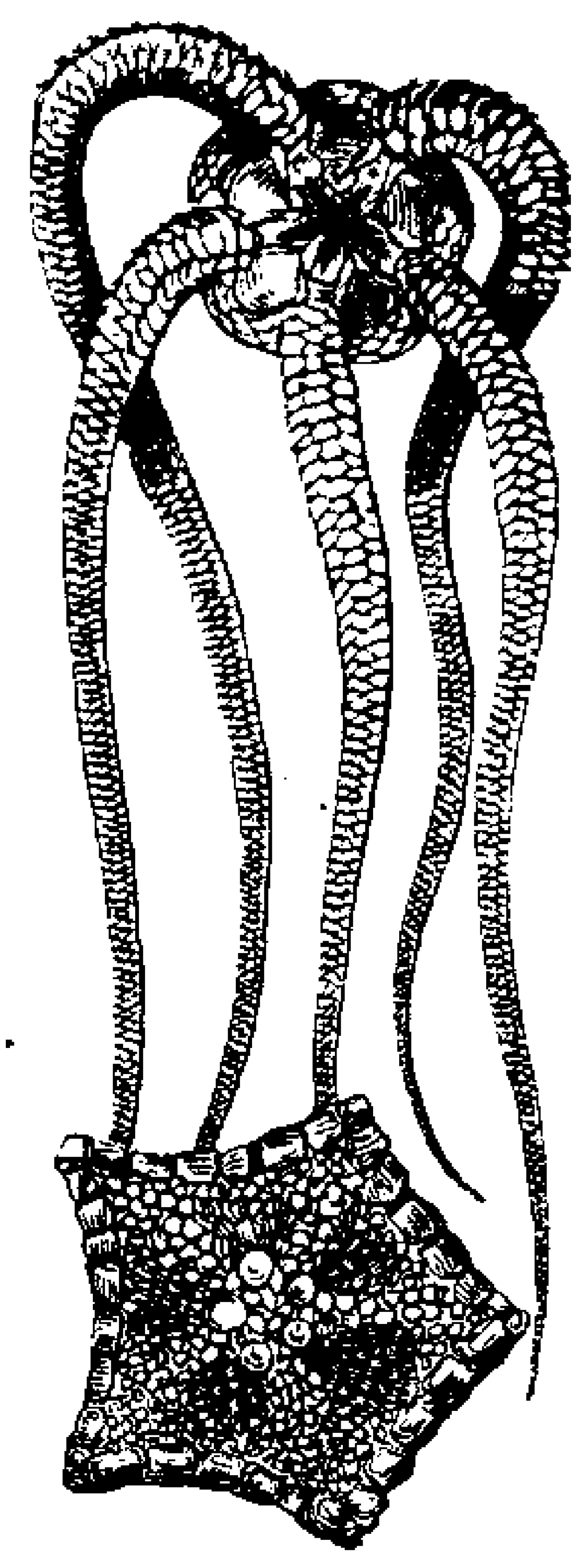
colour dotted with brown may serve to give us an idea of the beauty of the submarine landscapes where *Pentacrinus Wyville-Thomsoni* or *Bathycrinus gracilis* abound. During the earlier stage of its existence, the comatula is attached to a stalk ; a discovery for which science is indebted to Mr. T. V. Thompson, who in 1823 dredged in the Cove of Cork a singular little pedunculated crinoid animal (*Pentacrinus europæus*), which he found attached to the stems of zoophytes. It measured about three-fourths of an inch in height, and resembled a minute *comatula* mounted on the stalk of a *pentacrinus*. When this pygmy representative of the ancient lily-stars was first dragged up from its submarine haunts, it created a great sensation among naturalists, as it was the first recent animal of the encrinite kind which had ever been seen in the seas of Europe. At first it was supposed to be a distinct species, but Mr. Thompson, by carefully following it through all the stages of its growth, succeeded in proving that it was merely the hitherto unnoticed young of the rosy feather-star.

This elegant crinoid is found all round our coasts, and its range extends from Norway to the shores of the Mediterranean. In swimming, the movements of its arms exactly resemble the alternating stroke given by the medusa to the liquid element, and have the same effect, causing the animal to raise itself from the bottom and to advance back foremost, even more rapidly than the medusa. When dying, either in fresh water or in spirits, it emits a most beautiful purple colour, which tinges the liquid in which it is killed.

The *Ophiuridæ*, or *snake-stars*, are essentially distinguished from the true *star-fishes* by the long serpent or worm-like arms, which are appended to their round, depressed, urchin-like bodies. They have no true suckers with which to walk, their progression being effected (and with great facility) by the twisting or wriggling of their arms, which are moreover in many species furnished with spines on the sides, assisting locomotion over a flat surface. These arms are very different from those of the true star-fishes, which are lobes of the animal's body, whereas the arms of the Ophiuridæ are mere processes attached or superadded to the body.

These animals are very generally distributed through the seas of our earth, both of its northern and southern hemi-

spheres, but are found largest in the tropical ocean. In our own waters they are very abundant, and are among the most curious and beautiful game pursued by the dredger.


Sand-star.

The British Ophiuridæ belong to two generic types, that of the *Ophiuræ* and that of the *Euryales*. The former, to which the sand and brittle-stars belong, have simple arms; the latter, arms ramifying into many processes.

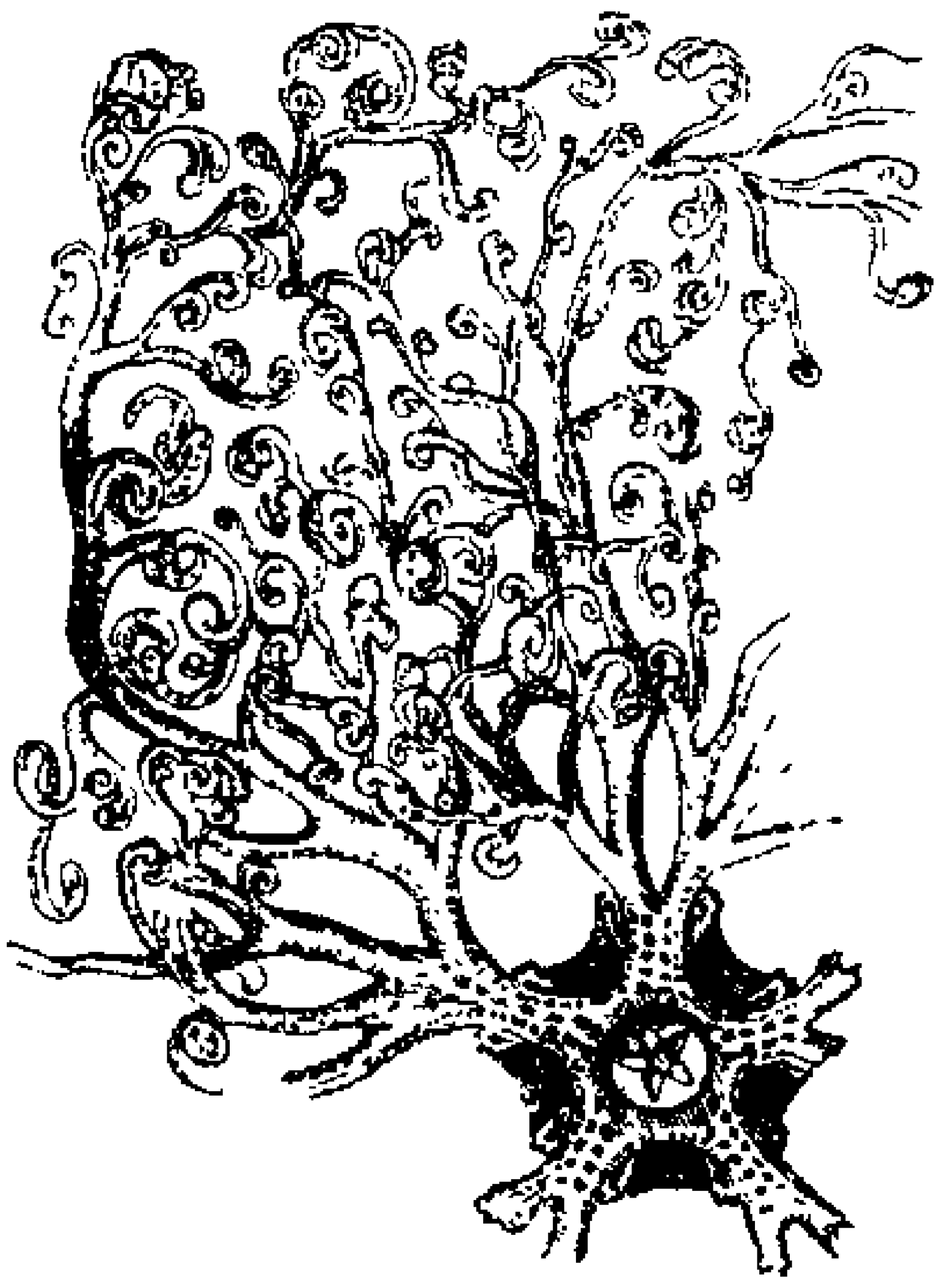
The rays of the Sand-stars have a whip-like or lizard-tail appearance, while those of the Brittle-stars look like so many centipedes or annelides attached at regular distances round a little sea-urchin. We have ten native brittle-stars, the most common of which (*Ophiocoma rosula*, Forbes) is also one of the handsomest, presenting every variety of variegation, and the most splendid displays of vivid hues arranged in beautiful patterns. Not often are two specimens found coloured alike. It is the most brittle of all brittle-stars, separating itself into pieces with wonderful quickness and ease. Touch it, and it flings away an arm; hold it, and in a moment not an arm remains attached to the body. "The common brittle-star," says Edward Forbes, "often congregates in great numbers on the edges of scallop-banks, and I have seen a large dredge come up completely filled with them; a most curious sight, for when the dredge was emptied, these little creatures, writhing with the strangest contortions, crept about in all directions, often flinging their arms in broken pieces around them; and their snake-like and threatening attitudes were by no means relished by the boatmen, who anxiously asked permission to shovel them overboard, superstitiously remarking that the things weren't altogether right."

Fancy the naturalist's vexation, who has no other means of preserving a brittle-star entire than by quickly plunging it into cold fresh water, which acts as a poison on the Ophiuræ as well as on most other marine animals, and kills them so instan-

taneously that even the most brittle species have no time to make the contraction necessary to break off their rays.

The *Ophiocoma rosula* seems to be equally abundant on all parts of the coast of Britain and Ireland. It is fond of rocky places, and grows in Shetland to a much larger size than elsewhere. It is said to prey on little shells and crabs, and is greatly relished by the cod in its turn, great numbers being often found in the stomach of that voracious fish.

The Scotch or Shetland Argus (*Euryale verrucosum*, Lamarck), a very rare animal, of which the adjoining wood-cut represents a segment, is the only British *Euryale*. It measures a foot or more across, and its singular aspect has long excited admiration among naturalists. "So odd a creature as this," remarks Bradley in his "Works of Nature," "is well worth the contemplation of such curious persons as live near the sea, where every day they have subjects enow to employ their curiosity and improve their understanding." Grew says that "as he swims he spreads and stretches out all his branches to their full length, and so soon as he perceives his prey within his reach, he hooks them all in, and so takes it as it were in a net."

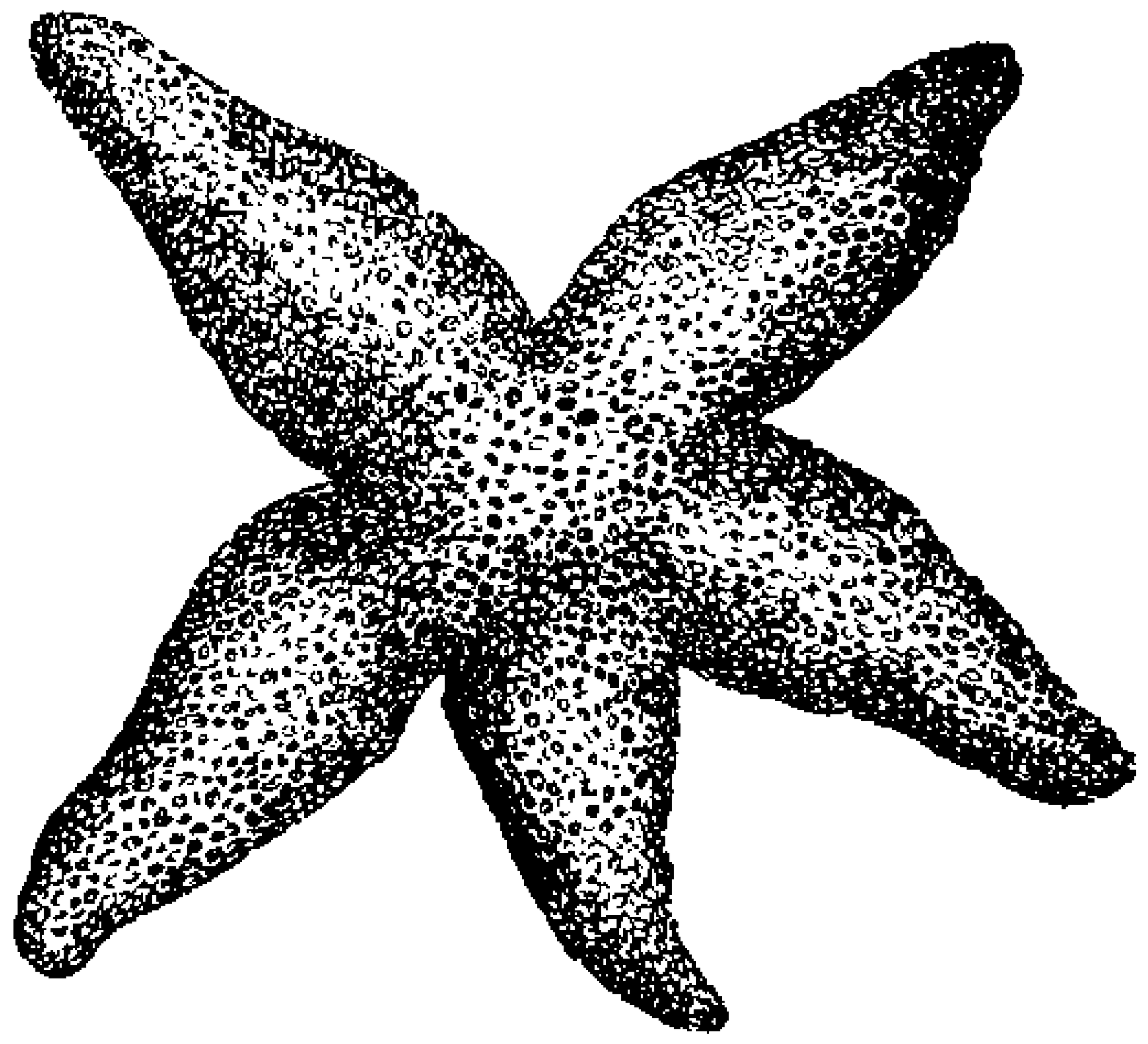


Warted Euryale.

The British species of true star-fishes may be arranged under four families. The *Urasters* are distinguished from all others by having four rows of suckers in each of the avenues which groove the under surface of their rounded rays. In consequence of the great number of these singular organs, the under surface of a living cross-fish presents a sight truly curious and wonderful. Hundreds of worm-like suckers, extending and contracting, coiling and feeling about, each apparently acting independently of the others, give the idea rather of an assemblage of polypi than of essential parts of *one* animal. They are sensitive in the extreme, for, if we touch one of those singular tubes when outstretched, all those in its neighbourhood are thrown into a state of agitation; and when it shrinks from our touch, changing

from a lengthy fibre to a little shrunk tubercle, some of its neighbours, as if partaking in its fears, contract themselves in like manner.

The common Cross-fish (*Uraster rubens*) abounds on most parts of our shores, so as in some places to be used for manure in large quantities. "It is a sworn enemy to oysters, and as it is frequently found with one or more of its rays broken off, the fishermen fancy that it loses them in consequence of its oyster-hunting propensities; that it insinuates an arm into the incautious oyster's gape, with the intent of whipping out its prey, but that sometimes the apathetic mollusk proves more than a match for its radiate enemy, and closing on him, holds him fast by the proffered finger; whereupon the cross-fish preferring amputation and freedom to captivity and dying of an oyster, like some defeated warrior flings his arms away, glad to purchase the safety of the remaining whole by the reparable loss of a part, as it has the power of reproducing the broken rays.



Common Cross-fish.

"There is, however, reason to think that the cross-fish destroys his prey in a very different manner from that just narrated; for star-fishes are not unfrequently found feeding on shell-fish, enfolding their prey within their arms, and seeming to suck it out of its shell with their mouths, pouting out the lobes of the stomach, which they are able to project in the manner of a proboscis. Possibly the stomach secretes an acrid and poisonous fluid, which, by paralysing the shell-fish, opens the way to its soft and fleshy parts."—*Forbes's Star Fishes.*

The *Solasters* are "suns in the system of sea-stars," and are entitled to this distinguished rank among the marine constellations by their many rays and brilliant hues. The *Solaster papposa*, or common Sun-star, with rays varying in number from twelve to fifteen, is one of the commonest, and at the same time handsomest, of all the British species. Sometimes the whole upper surface is deep purple, and frequently the

disk is red, and the rays white tipped with red. It grows to a considerable size, having been found eleven inches broad.

The Goniasters, or Cushion-stars, are distinguished from the allied species by their pentagonal form. One of the most singular of our native species is the Birdsfoot Sea-star (*Palmipes membranaceus*), being the thinnest and flattest of all its class. When alive it is flexible, like a piece of leather, and a person who had never seen it before would be apt to mistake it for the torn off dorsal integument of some gibbous goniaster. The colour is white, with a red centre and five red rays, proceeding one to each angle. The whole upper surface is covered with tufts of minute spines arranged in rows.

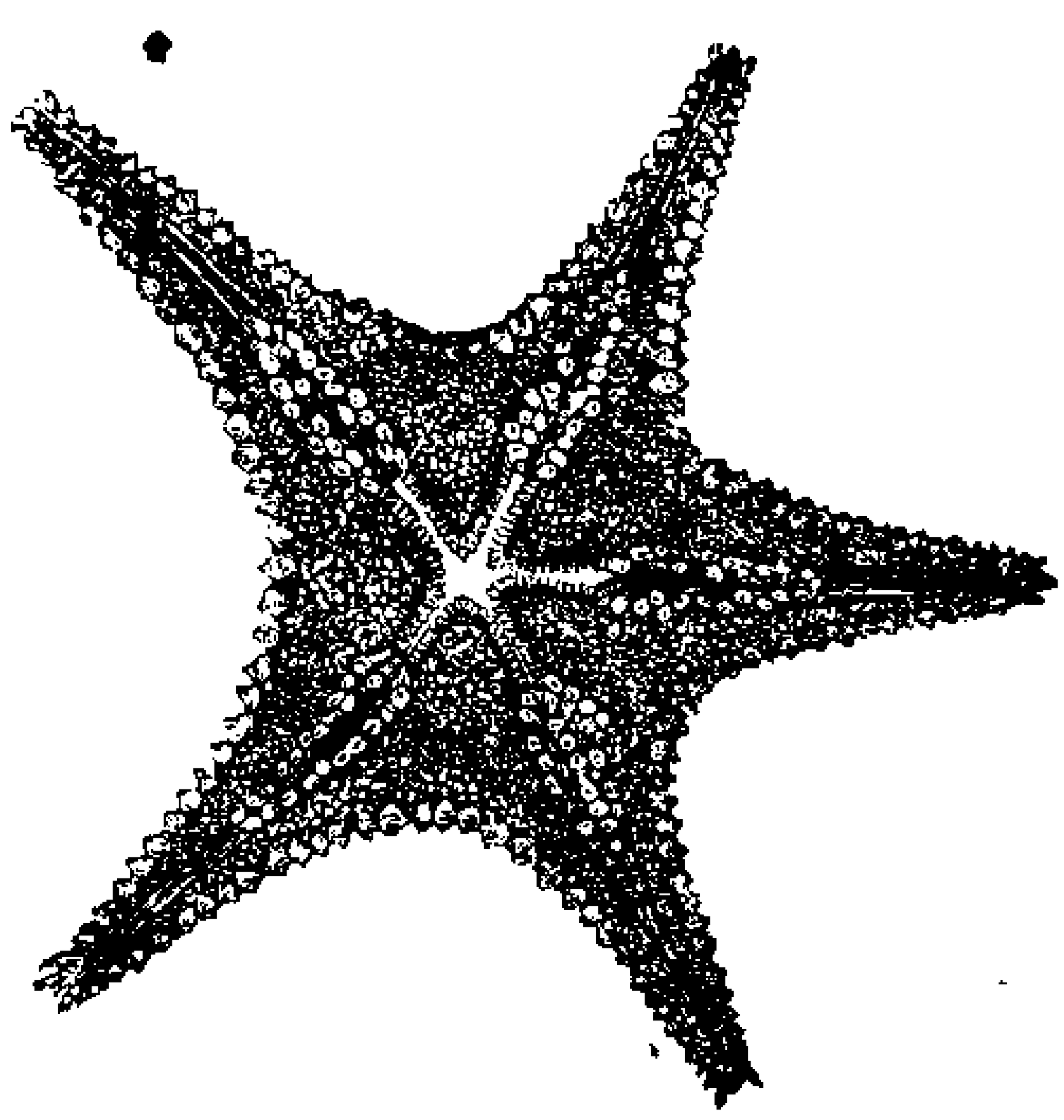
The Asteriæ, with their stellate body and flat rays, are very different in aspect from the Goniasters. The Butt-thorn (*Asterias aurantiaca*) owes its name to one of those strange superstitions which originate in some inexplicable manner, and are handed down by one credulous generation to the next. "The first taken by the fishermen at Scarborough is carefully made a prisoner, and placed on a seat at the stern of the boat. When they hook a butt (halibut) they immediately give the poor star-fish its liberty and commit it to its native element; but if their fishery is unsuccessful it is left to perish, and may eventually enrich the cabinet of some industrious collector."

To the family of the Asteriæ belongs also the Ling-thorn (*Luidia fragilissima*), the largest, and one of the most interesting of our British species. When full grown, it measures two feet across, and would appear to exceed that size occasionally, judging from fragments. The rays are from five to seven in number, quite flat, and generally five times as long as the disk is broad. The colour is brick-red above, varying in intensity, the under surface being straw-coloured. The wonderful power which the Luidia possesses, not merely of casting away its arms entire, but of breaking them voluntarily into little pieces with great rapidity, approximates it to the brittle-stars, and renders the preservation of a perfect specimen a very difficult matter.

"The first time I ever took one of these creatures," says Edward Forbes, "I succeeded in getting it into the boat entire. Never having seen one before, and quite unconscious of its suicidal powers, I spread it out on a rowing-bench, the better to admire its form and colours. On attempting to move it for

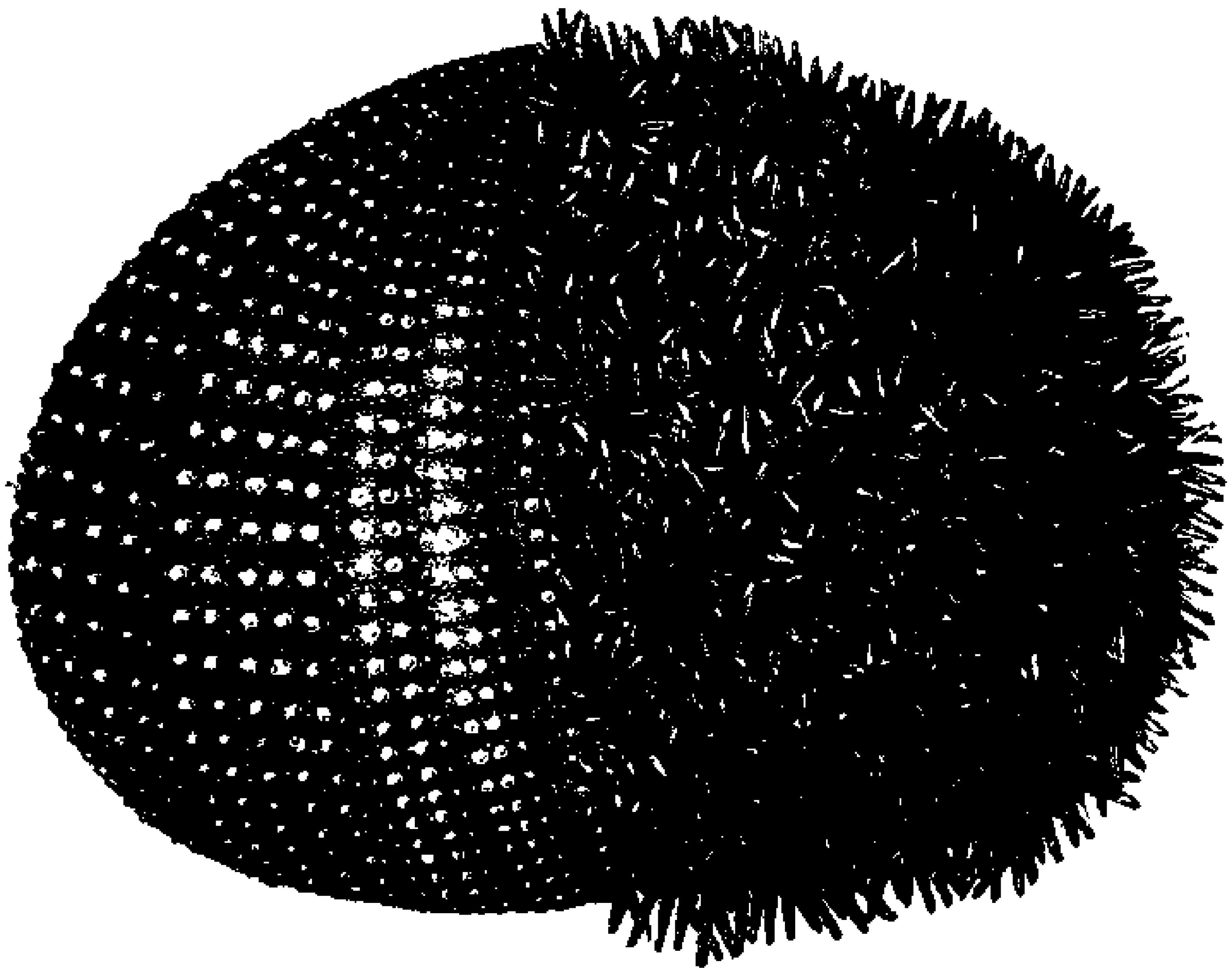
preservation, to my horror and disappointment I found only an assemblage of rejected members. My conservative endeavours were all neutralised by its destructive exertions, and it is now badly represented in my cabinet by an armless disk and a diskless arm. Next time I went to dredge on the same spot, determined not to be cheated out of a specimen in such a way a second time, I brought with me a bucket of cold fresh water, to which article star-fishes have a great antipathy. As I expected, a luidia came up in the dredge, a most gorgeous specimen. As it does not generally break up before it is raised above the surface of the sea, cautiously and anxiously I sunk my bucket to a level with the dredge's mouth, and proceeded in the most gentle manner to introduce luidia to the purer element. Whether the cold air was too much for him, or the sight of the bucket too terrific, I know not, but in a moment he proceeded to dissolve his corporation, and at every mesh of the dredge his fragments were seen escaping. In despair I grasped at the largest, and brought up the extremity of an arm with its terminating eye, the spinous eyelid of which opened and closed with something exceedingly like a wink of derision."

The Sea-star might be called a flattened sea-urchin, with radiated lobes, and the Sea-urchin, a contracted or condensed sea-star, so near is their relationship. In both we find the same radiating construction, in which the number five is so conspicuous, and in both also the rows of suckers, which, starting from a centre, are set into motion by a similar mechanism, and used for the same purpose. In all the sea-urchins finally, and in many of the sea-stars, we find the surface of the body covered with numerous exceedingly minute, two- or three-forked pincers, that perpetually move from side to side, and open and shut without intermission. These active little organs, which have been named *Pedicellariæ*, were formerly supposed to be parasites, working on their own account, but they are now almost univer-



Goniaster.

sally recognised as organs subservient to the nutrition of the animal, and destined to seize the food floating by, and to convey it to the mouth, one passing it to the other. Even in their outward appearance, the sea-urchins are not so very different from the sea-stars as would be imagined on seeing a Butt-thorn near a globular urchin, for both orders approach each other by



Shell of Echinus, or Sea-Urchin.
On the right side covered with spines, on the left the spines removed.

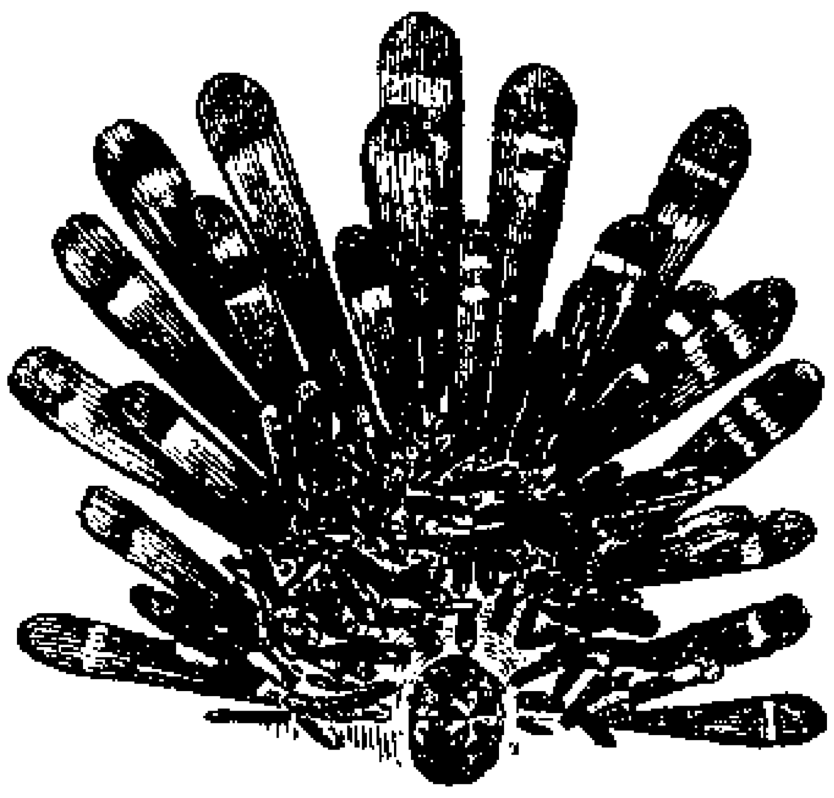
gradations; thus, the Goniasters, with their cushion-shaped disks and shortened rays, approximate very much in shape to the sea-urchins; and among the latter we also find a gradual progression from the flattened to the globular form. Still there are notable differences between the two classes. Thus in the sea-urchins the digestive organs form a tube with two openings, while in the true sea-stars they have but one single orifice. Their mode of life is, however, identical.

The Echinidæ move forward by means of the joint action of their suckers and spines, using the former in the manner of the true star-fishes, and the latter as the snake-stars. They also make use of the spines, which move in sockets, to bury themselves in the fine sand, where they find security against many enemies.

Some species even entomb themselves pholas-like in stone, inhabiting cavities or depressions in rocks, corresponding to their size, and evidently formed by themselves. Bennett describes each cavity of the edible *Echinus lividus* as circular, agreeing in form with the urchin within it, and so deep as to embrace more than two-thirds of the bulk of the inhabitant.

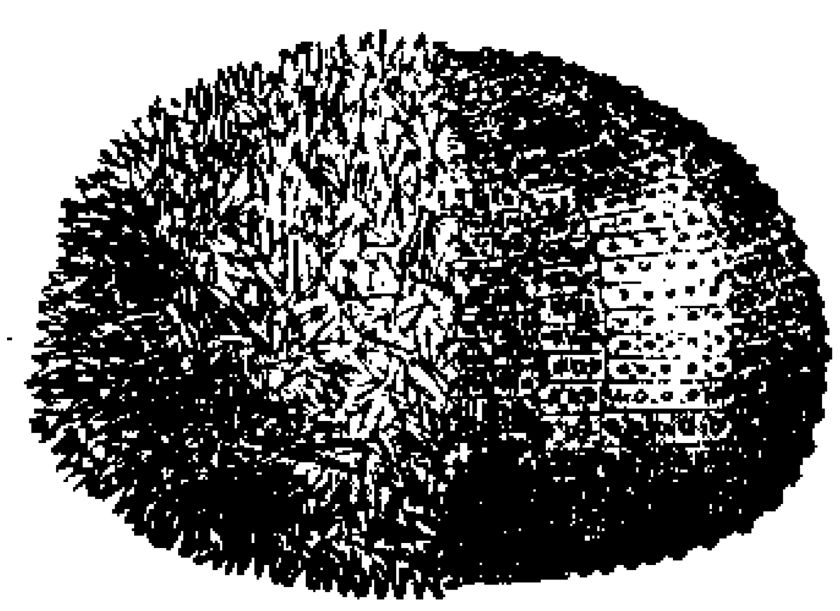
It is large enough to admit of the creature's rising a little, but not of its coming out easily. The echinus adheres so firmly to this cavity by its suckers, as to be forced from it with extreme difficulty when alive. On the coasts of the county of Clare thousands may be seen lodged in the rock, their purple spines and regular forms presenting a most beautiful appearance on the bottoms of the grey limestone rock-pools. How the boring is performed has, like many other secrets, not yet been settled by naturalists. The first perforation is most likely effected by means of the teeth, and then the rock softened by some secreted solvent.

Sea-urchins are found in all seas, but as they are extremely difficult to preserve, and many of them have such long and delicate spines that it is almost impossible to procure perfect specimens, probably not one tithe of their species is known.

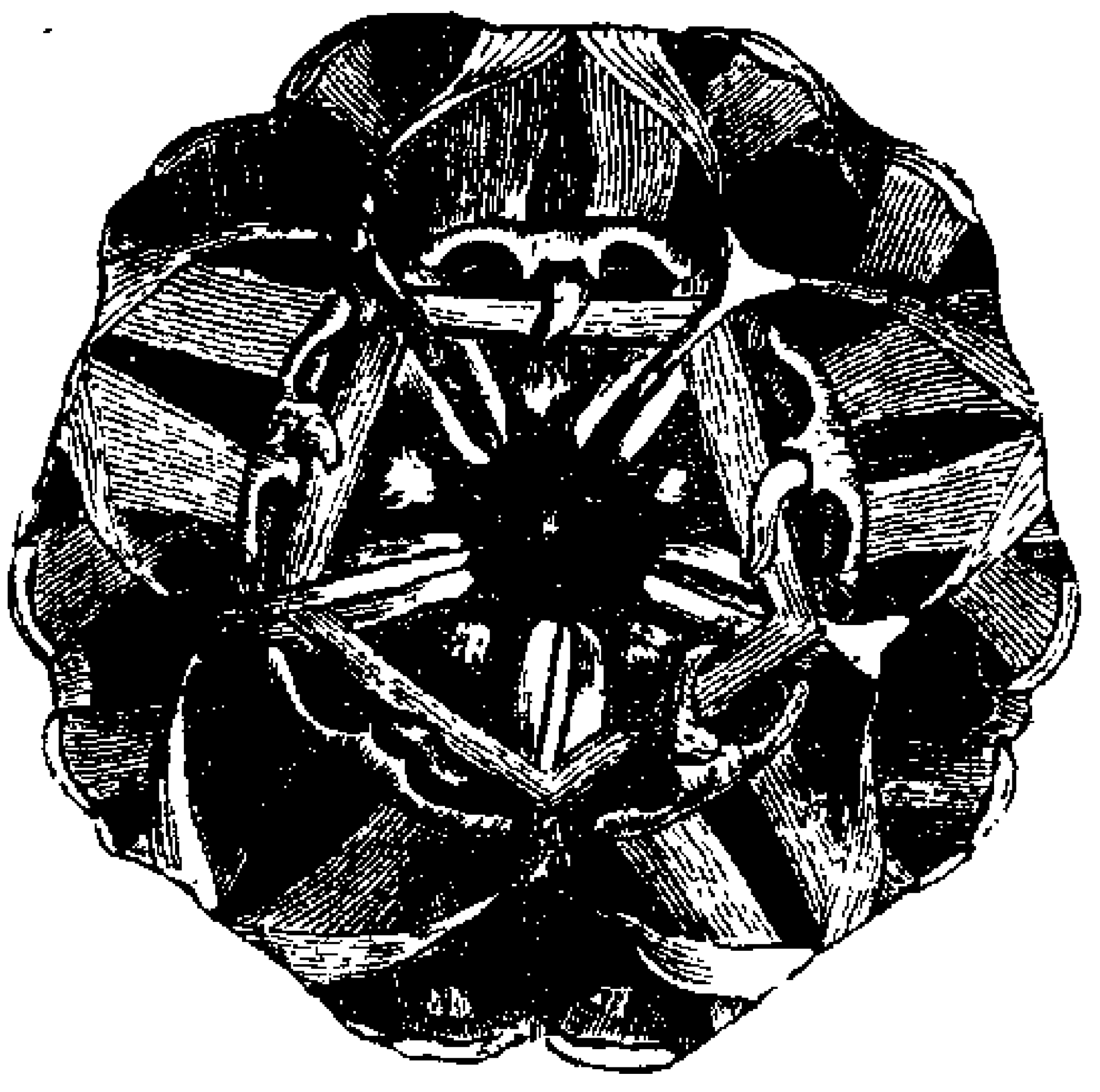

Mammillated Sea-Urchin.

On our coasts the common "egg-urchin" affords the poor a somewhat scanty repast; but, throughout the Mediterranean, its greater size, and also that of its allies, *Echinus melo* and *E. sardicus*, render them, when "in egg," important articles of food. In Sicily these animals are in season about the full moon of March; there the *E. esculentus* is still called the "King of Urchins;" whilst the larger melon-urchin is popularly considered to be its mother. The size and abundance of these edible species are among the striking peculiarities of the fish markets of the Mediterranean sea-board.

The calcareous shell of the "sea-urchin" seems, at first sight, to be composed of one simple crust, but proves, on nearer inspection, to be a masterpiece of mosaic consisting of several hundred parts, mostly pentagonal. These are so closely united that their junctions are hardly visible, but on allowing the shell to macerate for some days in fresh water, it falls to pieces. This complicated structure is by no means a mere architectural fancy, a useless exuberance of ornament, but essentially necessary to the requirements of the animal's growth. A simple hard crust would not have been capable of distension,

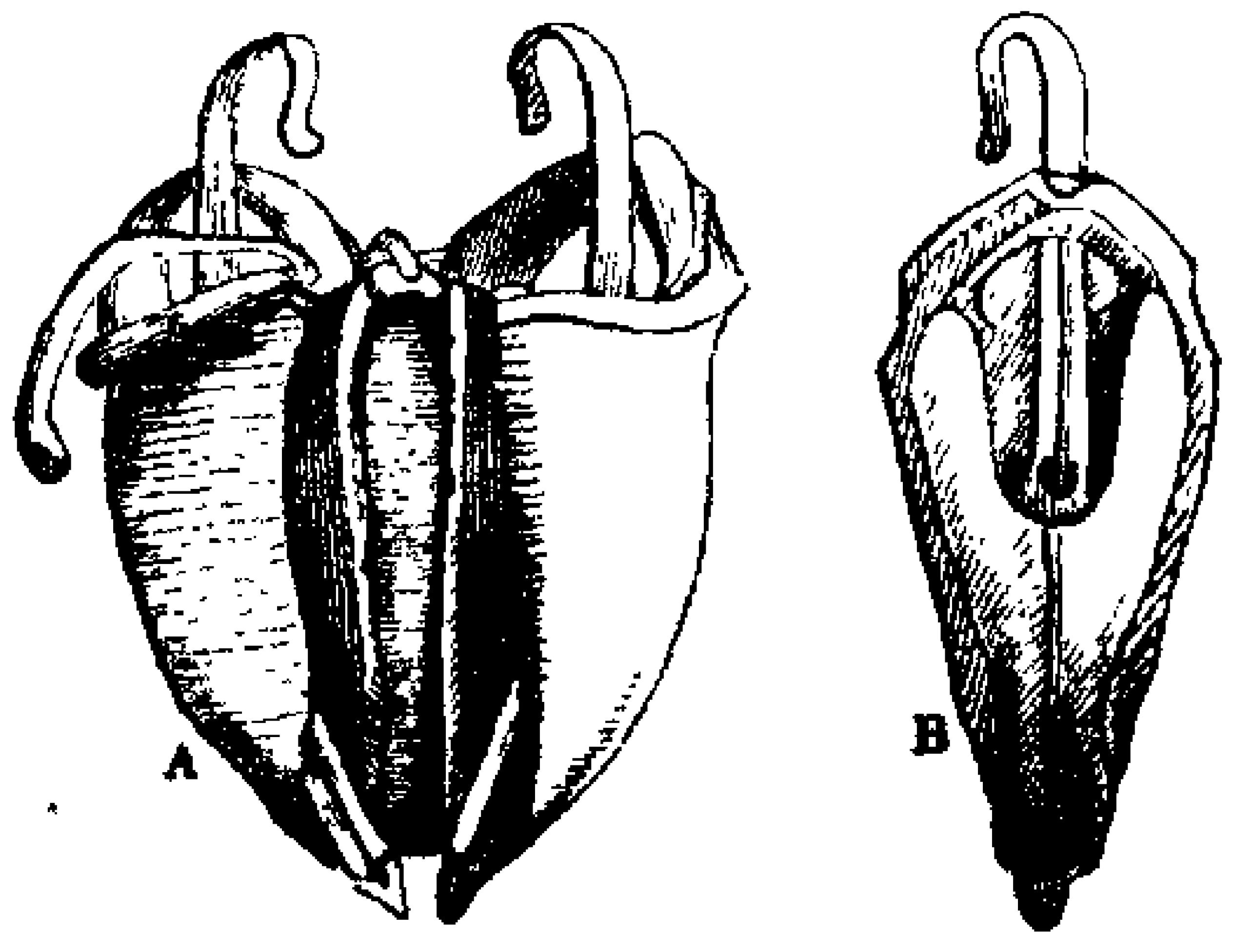

Edible Sea-Urchin.

whereas a complicated shell, such as the sea-urchin possesses, can grow in the same ratio as the internal parts, by continual deposits on the edges of the individual pieces. On closely examining a living sea-urchin, we find the whole surface of the shell and spines covered with a delicate skin, which, in spite of their close connexion, penetrates into the intervals of the several pieces. This membrane secretes the chalk of which the shell is composed, and deposits fresh layers on the edges of the plates, so that in this manner the shell continually widens until the animal has attained its perfect size. The spines are secreted in the same manner, and show under the microscope an admirable beauty and regularity of structure. So bountifully has the great Architect of worlds provided for the poor insignificant sea-urchin!



Dental Apparatus of the Sea-urchin, viewed from above.

The dental apparatus of the animal — the so-called lantern of Aristotle—is another masterpiece in its way. Fancy five triangular bones or jaws, each provided with a long, projecting, movable tooth. A complicated muscular system sets the whole machinery going, and enables the jaws to play up and down, and across, so that a more effective grinding-mill can scarcely be imagined.



A, Two sockets with teeth, of Echinus esculentus. B, Single socket with its tooth viewed on the outside.

The *Holothuriæ*, or Sea-cucumbers, may be regarded in one light as soft sea-urchins, and in another as approximating to the Annelides or worms. Their suckers are similar to those of the true star-fishes and sea-urchins. Besides progression by means of these organs, they move, like annelides, by the extension and contraction of their bodies. The mouth is surrounded by plumose tentacula, the

number of which, *when they are complete*, is always a multiple of five. They all have the power of changing their shapes in the strangest manner, sometimes elongating themselves like worms, sometimes contracting the middle of their bodies, so as to give themselves the shape of an hour-glass, and then again blowing themselves up with water, so as to be perfectly globular.

The great Sea-cucumber is the largest of all the known European species, and probably one of the largest *Cucumeriæ* in the world, measuring when at rest fully one foot, and capable of extending itself to the length of three. Under the influence of terror, it dismembers itself in the strangest manner. Having no arms or legs to throw off, like its relations the luidia and the brittle-star, it simply disgorges its viscera, and manages to live without a stomach; no doubt a much greater feat than if it contrived to live without a head. According to the late Sir James Dalyell, the lost parts are capable of regeneration, even if the process of disgorgement went so far as to leave but an empty sac behind. Considering the facility with which the sea-cucumber separates itself from its digestive organs, it is the more to be wondered how it tolerates the presence of a very remarkable parasite, a fish belonging to the genus *Fierasfer*,

Fierasfer.

and about six inches long. This most impudent and intrusive comrade enters the mouth of the cucumber, and, as the stomach is too small for his reception, tears its sides, quartering himself without ceremony between the viscera and the outer skin. The reason for choosing this strange abode is as yet an enigma.

The *Holothuriæ*, which in our part of the globe are very little noticed, play a much more important part in the Indian Ocean, where they are caught by millions, and, under the name of *Trepang* or *Biche de mer*, brought to the markets of China and Cochin-China. Hundreds of praos are annually fitted out in the ports of the Sunda Islands for the gathering of trepang; and sailing with help of the

Eatable Trepang.

western monsoon to the eastern parts of the Indian Archipelago, or along the northern coast of Australia, return home again by favour of the eastern monsoon. The bays of the inhospitable treeless shores of tropical New Holland, the abode of a few half-starved barbarians, are enlivened for a few months by the presence of the trepang fishers.

"During my excursions round Raffles Bay," says Dumont d'Urville, ("Voyage to the South Pole,") "I had remarked here and there small heaps of stones surrounding a circular space. Their use remained a mystery until the Malayan fishers arrived. Scarce had their praos cast anchor, when without loss of time they landed large iron kettles, about three feet in diameter, and placed them on the stone heaps, the purpose of which at once became clear to me. Close to this extemporised kitchen they then erected a shed on four bamboo stakes, most likely for the purpose of drying the holothurias in case of bad weather. Towards evening, all preliminaries were finished, and the following morning we paid a visit to the fishermen, who gave us a friendly reception. Each prao had thirty-seven men on board, and carried six boats, which we found busily engaged in fishing. Seven or eight Malays, almost entirely naked, were diving near the ship, to look for trepang at the bottom of the sea. The skipper alone stood upright, and surveyed their labours with the keen eye of a master. A burning sun scorched the dripping heads of the divers, seemingly without incommoding them; no European would have been able to pursue the work for any length of time. It was about noon, and the skipper told us this was the best time for fishing, as the higher the sun, the more distinctly the diver is able to distinguish the trepang crawling at the bottom. Scarce had they thrown their booty into the boat when they disappeared again under the water, and as soon as a boat was sufficiently laden, it was instantly conveyed to the shore, and succeeded by another.

"The holothuria of Raffles Bay is about six inches long, and two inches thick. It forms a large cylindrical fleshy mass, almost without any outward sign of an organ, and as it creeps very slowly along is easily caught. The essential qualities of a good fisherman are great expertness in diving, and a sharp eye to distinguish the holothurias from the similarly coloured sea-bottom.

The trepang is first thrown into a kettle filled with boiling sea-water. After a few minutes, it is taken out of its hot-bath and ripped open with a knife to cleanse it of its intestines. It is then thrown into a second kettle, where a small quantity of water and the torrefied rind of a mimosa produce dense vapours. This is done to smoke the trepang for better preservation. Finally, it is dried in the sun, or in case of bad weather under the above-mentioned shed. I tasted the trepang, and found it had some resemblance to lobster. In the China market the Malays sell it to the dealers for about fifteen rupees the picul of 125 pounds. From the earliest times, the Malays have possessed the monopoly of this trade in those parts, and Europeans will never be able to deprive them of it, as the economy of their outfit and the extreme moderation of their wants forbid all competition. About four in the afternoon the Malays had terminated their work. In less than half an hour the kettles and utensils were brought on board, and before nightfall we saw the praos vanish from our sight."

The inhabitants of the island of Waigiou, to the north of New Guinea, prepare the trepang in the Malay manner, and barter it for cotton and woollen stuffs, which are brought to them by some Chinese junks. "In every hut," says Lesson, "we found great heaps of this dried leathery substance, which has no particular taste to recommend it, and is so highly esteemed by the Chinese for no other reason than because they ascribe to it,— as to some other gelatinous substances, as agar-agar, shark-fins, and edible bird's nests,—peculiar invigorating properties, by means of which their enervated bodies are rendered fit for new excesses."

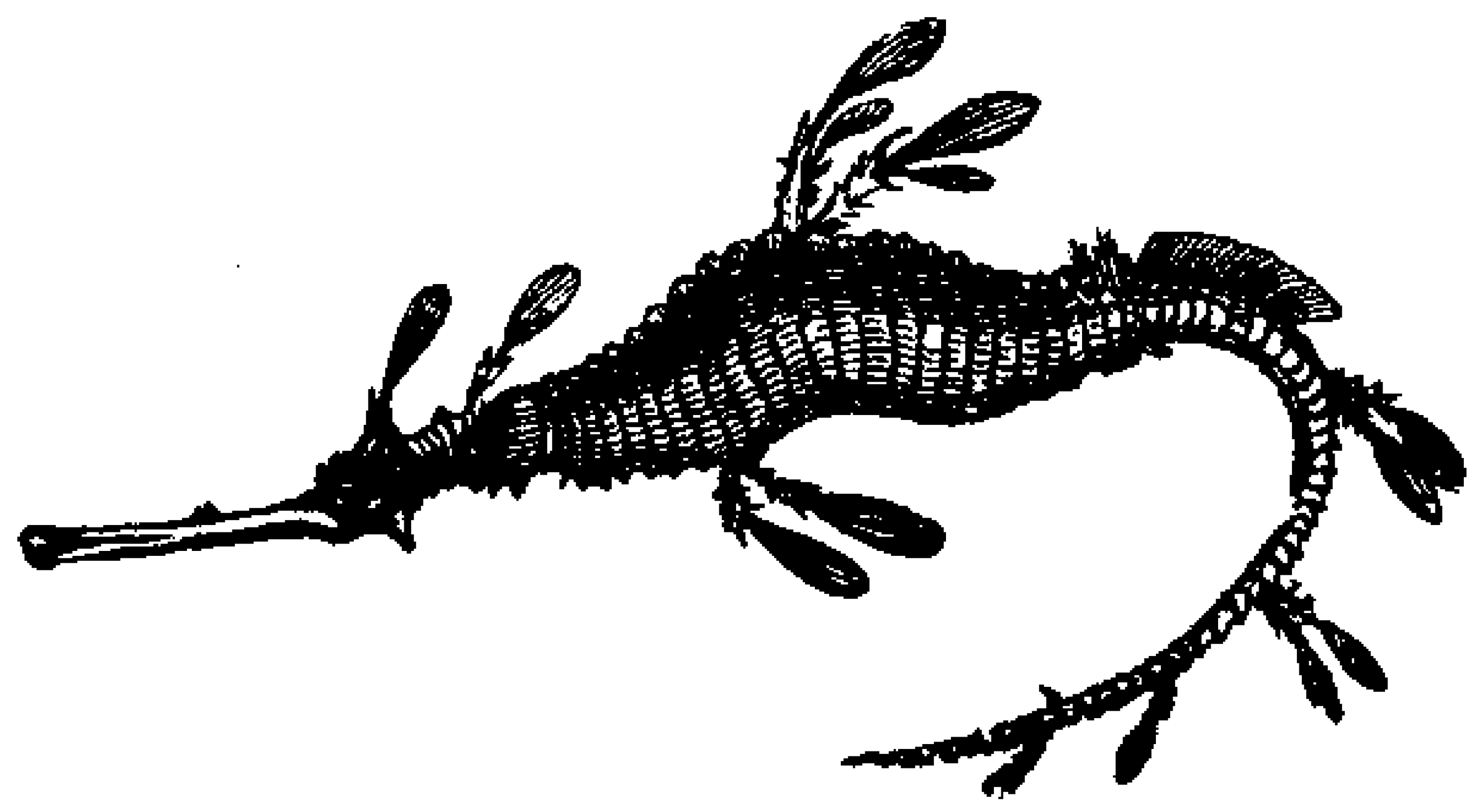
The Feejee islanders have the reputation of being the greatest cannibals and the most perfidious savages of the whole Pacific, yet the trepang fishery attracts many American and European speculators to that dangerous archipelago. Captain Wilkes, of the United States Exploring Expedition, found there a countryman, Captain Eagleston, who had been successful in more than one of these expeditions, and obligingly communicated to him all the particulars of his adventurous trade. There are six valuable sorts of biche de mer, or trepang; the most esteemed is found on the reefs one or two fathoms deep, where it is caught by diving. The inferior sorts occur on reefs which are dry, or nearly so, at low water, where they are picked up by the natives, who also

fish the biche de mer on rocky coral bottoms by the light of the moon or of torches, as they come forth by night to feed. The most lucrative fisheries are on the northern side of Viti Levu. They require a large building for drying, with rows of double staging, on which reeds are placed. Slow fires are kept up by natives underneath, about fifteen hands being required to do the ordinary work of a house.

Before beginning, the services of some chief must be secured, who undertakes the building of the house, and sets his dependants at work to fish. The usual price is a whale's tooth for a hogshead of the animals just as they are taken on the reef; but they are also bought with muskets, powder, balls, vermilion, blue beads, and cotton cloth of the same colour. When the animals are brought on shore, they are measured into bins containing about fifty hogsheads, where they remain until next day. They are then cut along the belly for a length of three or four inches, taking care not to cut too deep, as this would cause the fish to spread open, which would diminish its value. They are then thrown into boilers, two men attending each pot, and relieving each other, so that the work may go on night and day. No water need be added, as the fish itself yields moisture enough to prevent burning. After draining on a platform for about an hour, they are taken to the house and laid four inches deep upon the lower battens, and afterwards upon the upper ones, where they remain three or four days. Before being taken on board they are carefully picked, all damp pieces being removed. They are stowed in bulk, and sold in Manilla or Canton by the picul, which brings from fifteen to twenty-five dollars. In this manner Captain Eagleston had collected in the course of seven months, and at a trifling expense, a cargo of 1200 piculs, worth about 25,000 dollars. The outfit is small, but the risk is great, as no insurance can be effected; and it requires no small activity and enterprise to conduct this trade. A thorough knowledge of native character is essential to success, and the utmost vigilance and caution must always be observed to prevent surprise, or avoid difficulties.

No large canoes should ever be allowed to remain alongside the vessel, and a chief of high rank should be kept on board as a hostage. That these precautions are by no means unnecessary, is proved by the frequent attempts of the savages to cut off

small vessels trading on their coasts. One of the most frequent methods is to dive and lay hold of the cable; this, when the wind blows fresh to the shore, is cut, in order that the vessel may drift upon it, or in other cases a rope is attached to the cable by which the vessel may be dragged ashore. The time chosen is just before daylight. The moment the vessel touches the land, it is treated as a prize sent by the gods, and the crew murdered, roasted, and devoured.



Sea-horse.

CHAP. XVII.

CŒLENTERATA.

POLYPS AND JELLY-FISHES.

Thread-cells or Urticating Organs.—Sertulariæ.—Campanulariadæ.—Hydrozoic Acalephæ.—Medusidæ.—Lucernariadæ.—Calycophoridæ.—The Velella.—The Portuguese Man-of-war.—Anecdote of a Prussian Sailor.—Alternating Fixed and Free-swimming Generations of Hydrozoa.—Actinozoa.—Ctenophora—Their Beautiful Construction.—Sea-anemones.—Dead Man's Toes.—Sea-pens.—Sea-rods.—Red Coral.—Coral Fishery.—Isis hippuris.—Tropical Lithophytes.—History of the Coral Islands—Darwin's Theory of their Formation—The progress of their Growth above the level of the Sea.

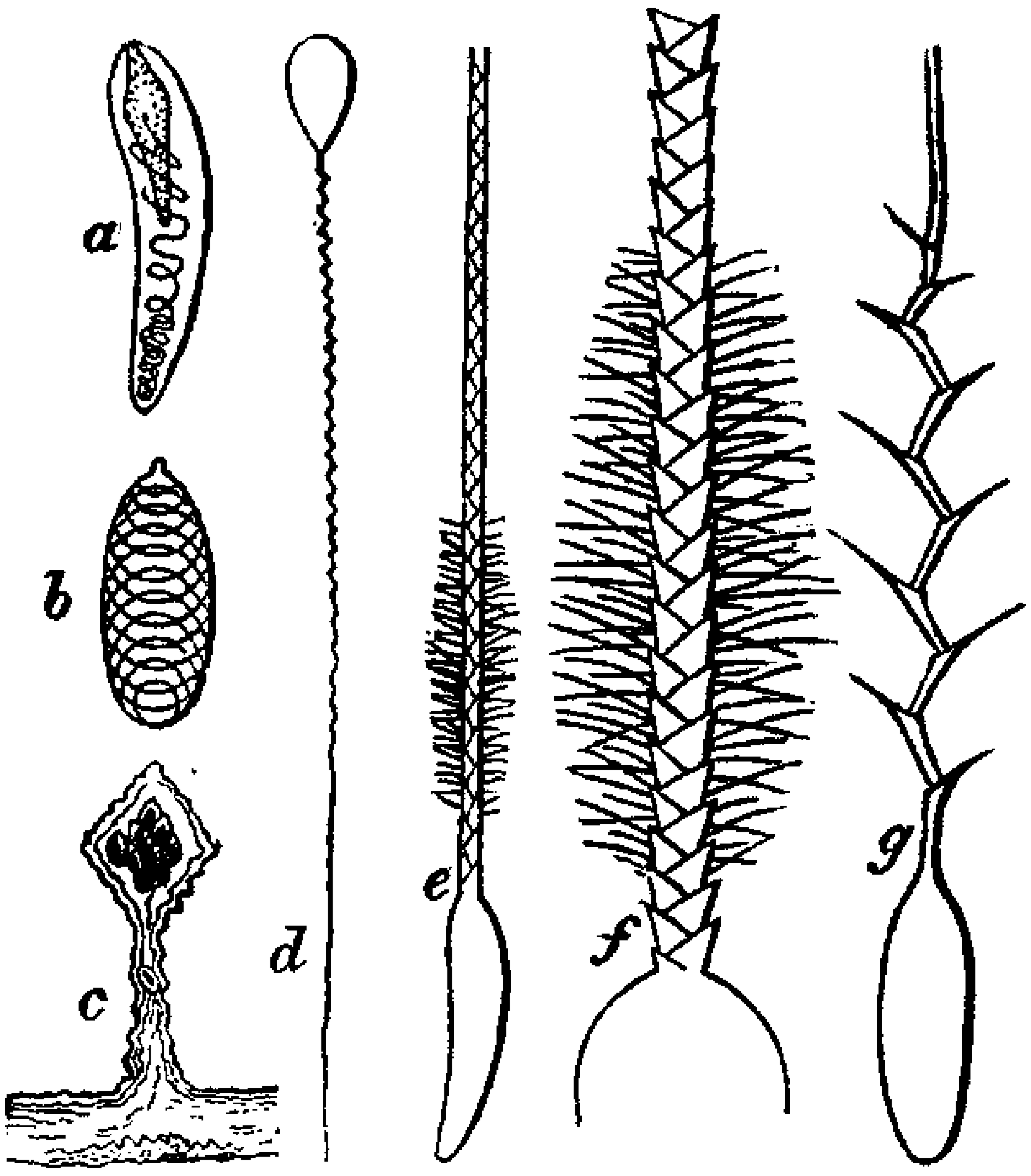
Despite the low rank they occupy in the hierarchy of animal life, the Cœlenterata, comprising the numerous families of the Jelly-fishes and Polyps, play a most important part in the household of the ocean, for the sea is frequently covered for miles and miles with their incalculable hosts, and whole archipelagos and continents are fringed with the calcareous structures they raise from the bottom of the deep.

Their organisation is more simple than that of the preceding classes, for they have neither the complex intestinal tube of the polyzoa or the sea-urchins nor the jointed rays or arms of the star-fishes; their whole digestive apparatus is but a simple sac, and their instincts are reduced to the mere prehension of the food that the currents bring within reach of their tentacles, or to the retraction of these organs when exposed to a hostile attack.

But, simple as they are, they have been provided by Nature with a comparatively formidable weapon in those remarkable "thread-cells," or urticating organs, which are so constantly met with in their integuments, and chiefly in their tentacles.

The thread-cells are composed of a double-walled sac having its open extremity produced into a short sheath terminating in

a long thread. A number of barbs or hooks are sometimes disposed spirally around the sheath, the thread itself being often delicately serrated. Under pressure or irritation the thread-cell suddenly breaks, its fluid escapes, and the delicate thread is so rapidly projected that the eye is utterly unable to follow the



Urticating Organs of Cœlenterata.

a, e, f. Threads and thread-cells of *Caryophyllia Smithii.* *b.* Thread-cell of *Corynactis Allmani.* *c.* Peculiar receptacle of *Willsia stellata*, containing thread-cells. *d.* A single thread-cell of the same. *g.* Thread-cell of *Actinia crassicornis.*—(All magnified.)

process. The violent protrusion of this barbed missile, along with the acrid secretion of the cell, causes many a worm or crustacean of equal or superior strength, that might have gone forth as victor from the struggle of life, to succumb to the cœlenterate, and is even in many cases exceedingly irritating to the human skin. Besides enabling its possessor to derive his subsistence from animals whose activity, as compared with his own, might be supposed to have removed them altogether out of the reach of danger, these stings serve also as admirable weapons of defence, and many a rapacious crab or annelide that would willingly have feasted upon a sea-anemone is no doubt repelled by the venomous properties of its urticating tentacles.

The Cœlenterata have been subdivided into two great classes: the Hydrozoa, in which the wall of the digestive sac is not separated from that of the cavity of the body, and the Actinozoa, in

which the stomach forms a distinct bag separated from the wall of the cavity of the body by an intervening space, subdivided into chambers by a series of vertical partitions. Each of these two classes comprises a number of families of various forms and habits of life. Thus among the Hydrozoa, with whom I begin my brief survey of cœlenterate life, some are of a compound nature (Sertularidæ, &c.), and, having once settled, remain permanently attached to the site of their future existence; while others (Rhizostomidæ, &c.) continue freely to roam through the water, and others again appear in the various stages of their development either as sessile polyps or as free-swimming Medusæ.

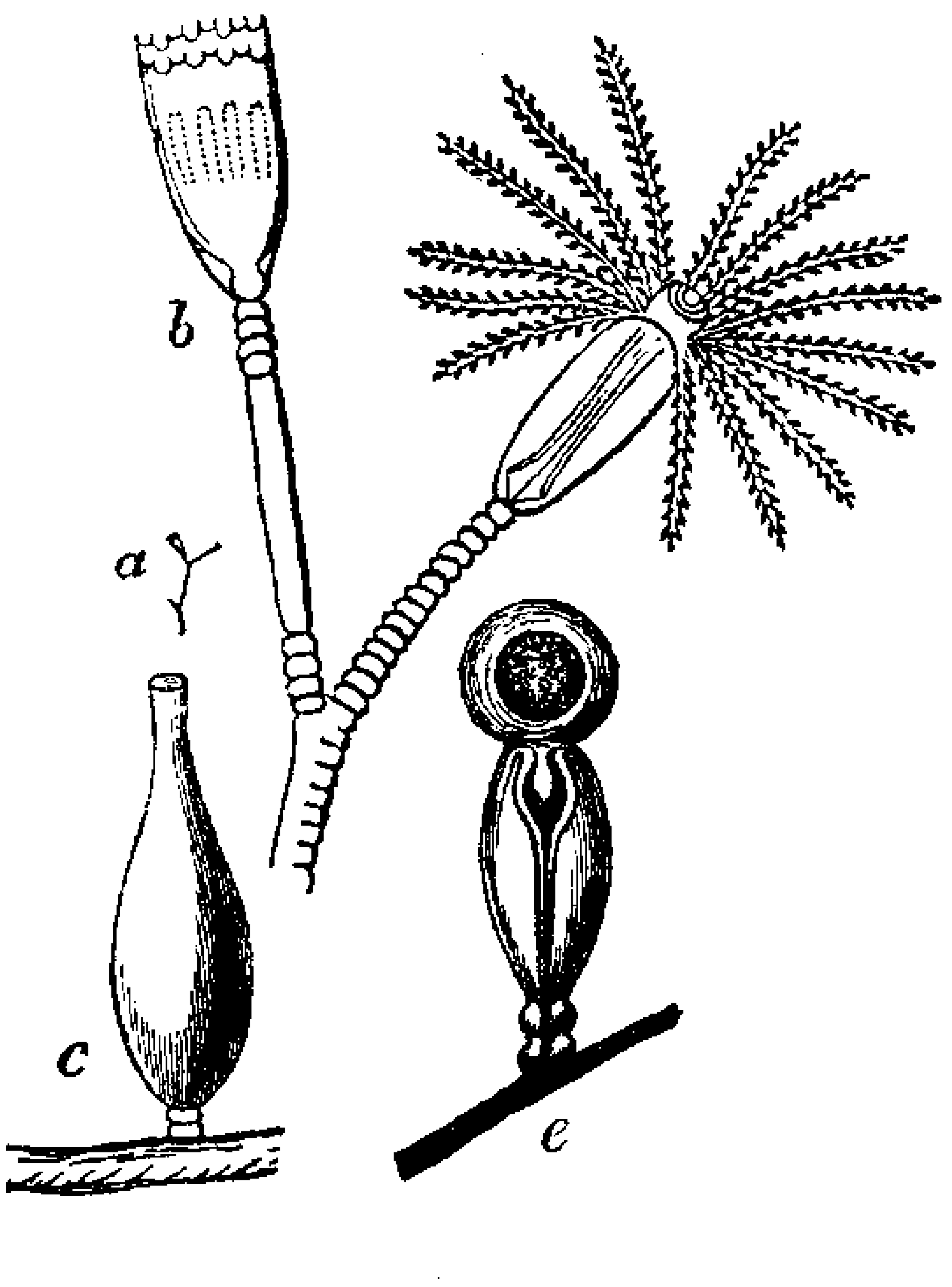
The sertularian tribes are remarkable for the elegance of their forms, resembling feathers more or less stiff and angular, more or less flexible and plumose. Their bleached skeletons are among the commonest objects thrown out by the waves, and so plant-like is their appearance and manner of growth that, like the Flustræ, they might easily be mistaken for sea-weeds.

Sertularia tricuspidata.

a. Skeleton (natural size). *b*. Portion of the same, highly magnified. κ. *Cœnosarc*, or common trunk. π'. *Hydrotheca*, or protective envelope of individual polyp. ρ'. *Gonoblastidium*, or reproductive germ or body.

Originally produced from a single ovulum, every species, by the evolution of a succession of buds, after an order peculiar to each, grows up to a populous colony, and simultaneously with its growth the fibres by which it is rooted extend, and at uncertain intervals give existence to similar bodies, whence new polypiferous shoots take their origin, for these root fibres are full of the same medullary substance with the rest of the body.

Thus the graceful sea-fir (*Sertularia cupressina*), the largest of our native species, may attain a height of two or three feet, and bear on its branches no less than 100,000 distinct microscopical polypi, each with its own crown of tentacles, and each of these armed with numerous thread-cells, as formidable in their way as the crustacean's claw or the annelide's embrace. But though each polyp has a certain share of independence yet its body is continuous with the more fluid pulp that fills the branches and stem of the common trunk, and by this means all the polyps of it are connected together by a living thread, and made to constitute a family whose workings are all regulated by one harmonious instinct. Each of these plant-like structures may therefore be considered as one animal furnished with a multitude of armed heads and mouths, and in all the other compound cœlenterates we find a similar organisation. All the soft parts of a sertularian polypary are enclosed in a horny sheath (*hydrosoma*) which develops peculiar cup-shaped processes (*hydrothecæ*) for the protection of each individual polyp, and capsules for the reproductive bodies (*gonoblastidia*) in which the ova are produced. The various modifications of form and structure of the polyps, of their hydrothecæ and gonoblastidia, give rise to a number of families, genera, and species. Thus in the Sertulariæ the polypites are sessile, biserial, alternate, or paired; sessile and uniserial in the Plumulariæ, and stalked in the Campanulariadæ.

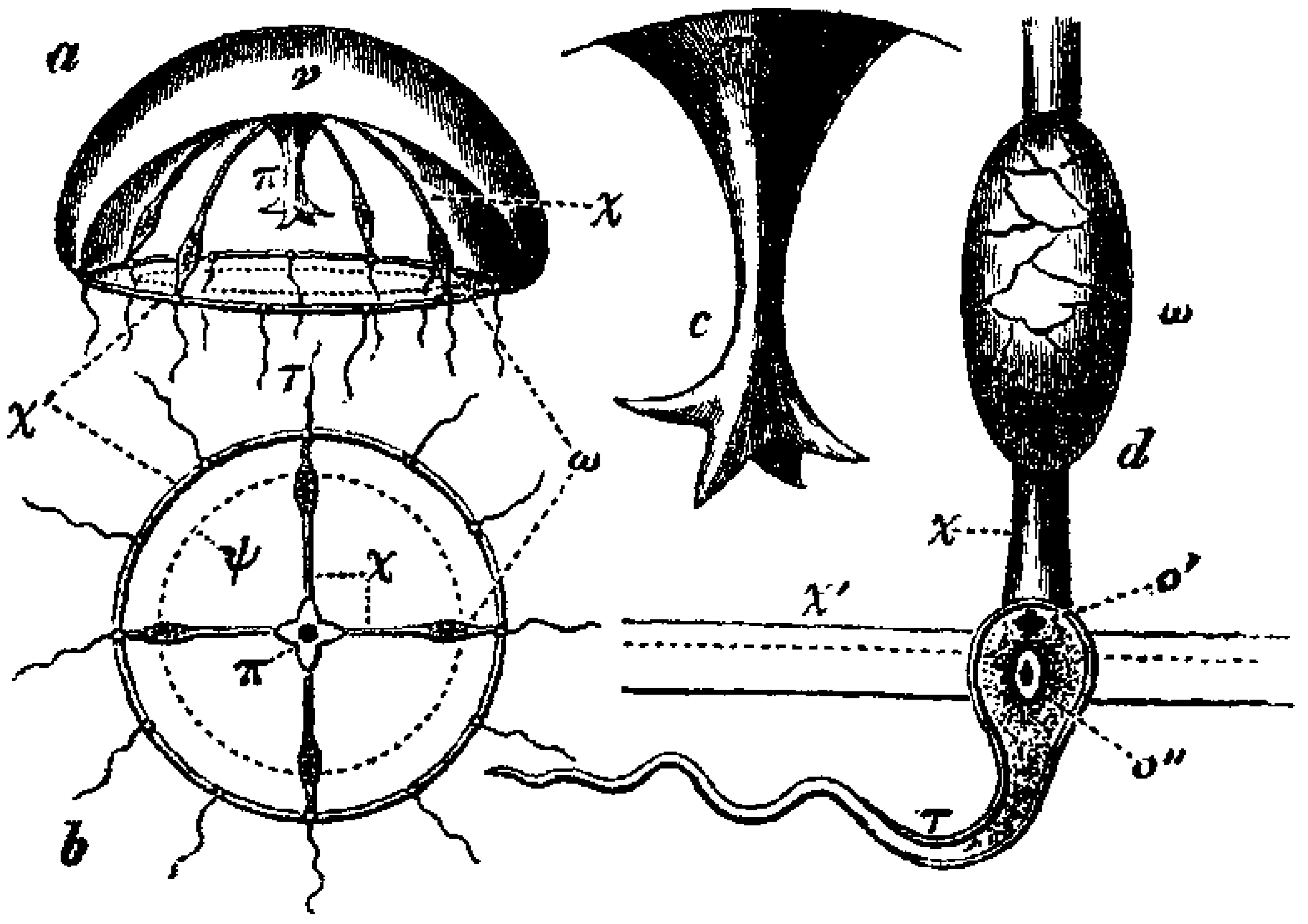


a. Laomedea neglecta, natural size.
b. Portion of the same, magnified.
c. Reproductive body of *Campanularia volubilis*.
e. Reproductive body of *C. syringa*.

The free-swimming Jelly-fishes, or Acalephæ, as they have been named by Aristotle on account of the stinging properties due to their urticating cells, are likewise among the commonest objects left upon our shores by the retreating tide. When stranded, they appear like gelatinous masses, disgusting to

the sight; but these shapeless objects were beautiful while they moved along in their own element, and their simple organisation shows no less the masterhand of the Creator than the complex structure of the higher stages of animal existence. With the exception of the Ctenophora, they all belong to the hydrozoic class, and from the great diversity of their structure have been ranged under four orders, Medusidæ, Lucernaridæ, Calycophoridæ, and Physophoridæ.

The Medusidæ are distinguished by their globular or bell-shaped disc, which by its alternate contractions and expansions forces them forward through the water. By contracting the whole or only part of its disc, the medusa has it in its power to

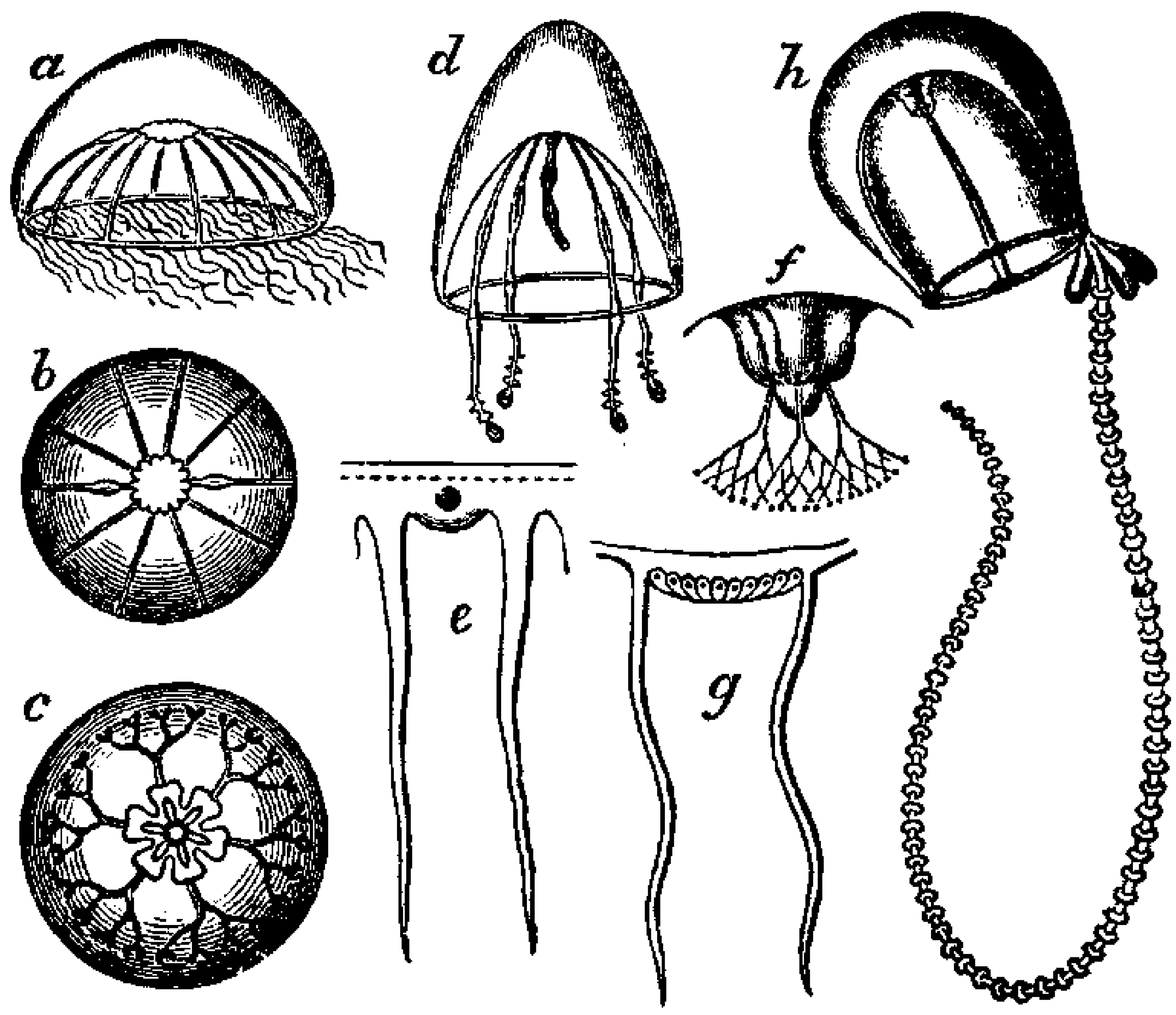


a. Medusid seen in profile. *b*. The same viewed from below. *c*. Its polypite. *d*. Part of its marginal canal, and other structures in connection therewith. ν. Disk or swimming organ. π. Polypite. ψ. Veil. τ. Tentacle. χ. Radiating canal. χ'. Marginal canal. ω. Reproductive organ. o'. Coloured spot. o''. Marginal vesicle.

direct its movements, and while thus swimming along with the convex side of the disc directed forwards, and its oral lobes and tentacles following behind like "streamers long and gay," it may well rank among the most elegant children of the sea.

From the roof of the disc a single polypite is suspended, whose mouth, generally produced into four lobes, though in some forms it is much more divided, passes into the central cavity (stomach) of the swimming organ, from which canals (either four in number, or multiples of four) radiate to join a circular vessel surrounding the margin of the bell. A shelf-like membrane or veil, extending around the margin, and highly contractile, assists locomotion by narrowing more or less the aperture

of the bell, and thus concentrating its efforts upon a narrower space. More or less numerous tentacles generally depend from the margin, and around it are disposed two kinds of remarkable bodies—"vesicles" and "pigment spots," or "eye-specks"—which are supposed to be able to communicate the impressions of light and sound. This complexity of organisation in creatures which Réaumur contemptuously styled mere lumps of animated jelly is all the more wonderful when we consider that they consist almost entirely of water, and shrink to a mere nothing when abandoned by their vital power. Thus of a medusa originally weighing many pounds but few traces remain



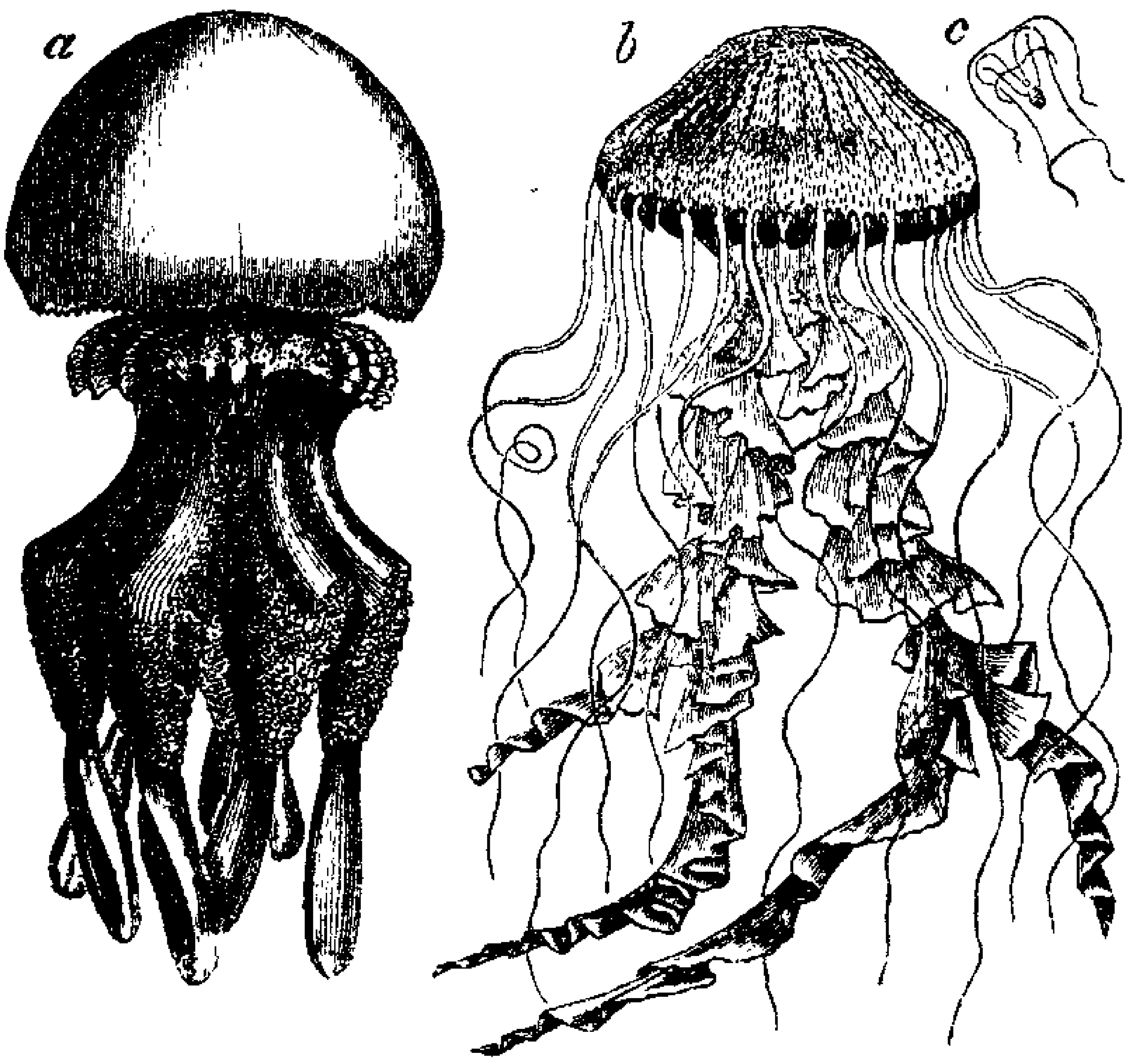
Various forms of Medusidæ.

a *Aequorea formosa*, seen in profile. b. The same, viewed from above. c. Upper view of *Willsia stellata*. d. *Slabberia conica*. e. Portion of the marginal canal of *Tiaropsis Pattersonii*. f. Polypite of *Bougainvillea dinema*. g. Part of its marginal canal. h. *Steenstrupia Owenii*. (a, b, and d are about the natural size; the others are magnified.)

after death; the ground is covered with a light varnish; all the rest has been absorbed by the thirsty sands.

The oceanic or free-swimming forms of the Lucernaridæ resemble the Medusidæ by their bell-shaped umbrella, but differ from them by their internal structure, by the absence of a marginal veil, by the nature of their canal system and marginal bodies, and by their mode of development. The radiating canals, never less than eight in number, send off numerous branches, which form a very intricate network, and the vesicles

and pigment-spots, here united into a single organ, termed the lithocyst, are each protected externally by a sort of hood, whence these jelly-fishes have been named "Stegonophthalmia," or "covered-eyed," by Forbes, to distinguish them from the naked-eyed "Gymnophthalmia," or Medusidæ. The Pelagidæ (Chrysaora), which form one of the divisions of this group, are simple, and have their margin surrounded with tentacles like the Medusidæ, while the Rhizostomidæ have no marginal tentacles, and consist of numerous polyps studding the trunks of a de-



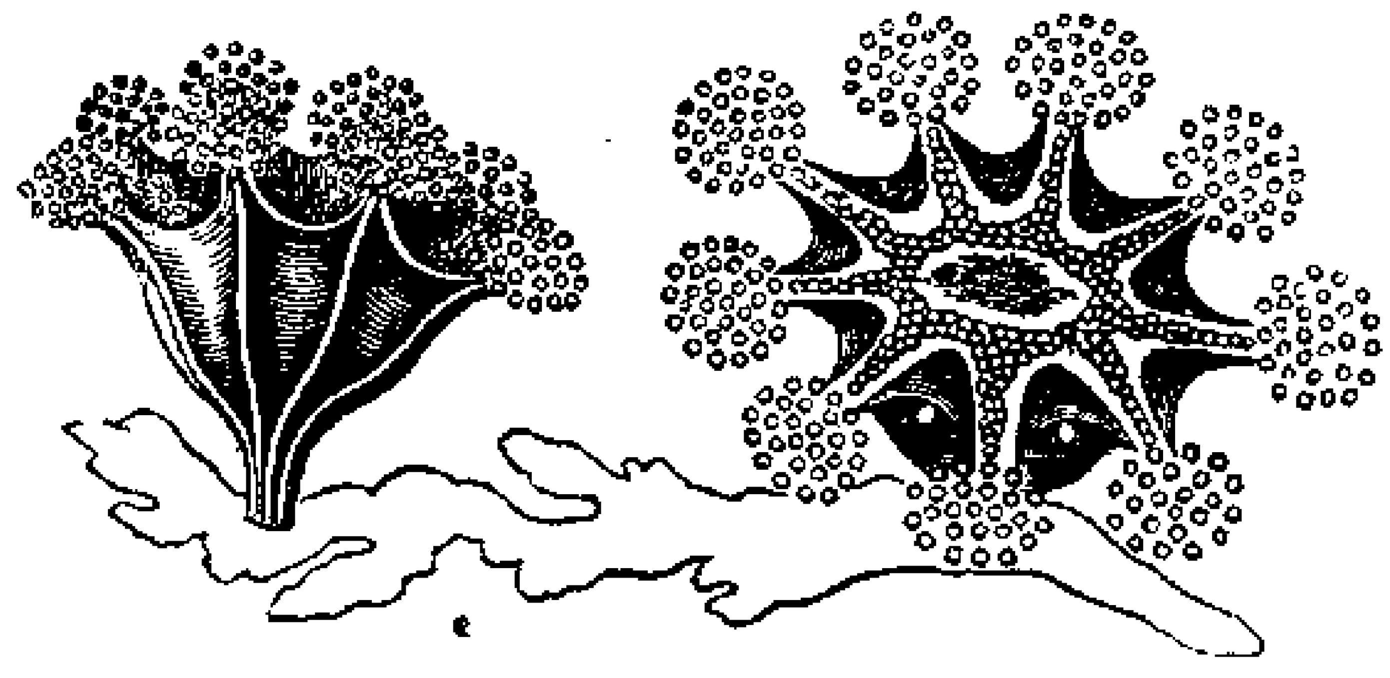
Oceanic forms of Lucernaridæ.

a. Rhizostoma pulmo. *b. Chrysaora hysoscella.* c. Its lithocyst.—(All reduced.)

pendent tree. These animals have consequently no central mouth, but hundreds of little mouths all active for the welfare of the community.

The sessile Lucernaridæ differ from the other members of the order by the narrow disc or stalk which serves to fix their body when at rest. Their quadrangular mouth is in the centre of the umbrella expansion, and round the margin of the cup arise a number of short tentacles, disposed in eight or nine tufts in Lucernaria, and forming one continuous series in Carduella.

Though generally preferring to lie at anchor, the Lucernariæ are able to detach themselves, and to swim in an inverted position by the slowly repeated movements of their cup-like umbrella. When in a state of expansion, few marine creatures exceed them in beauty and singularity of form; when contracted, they are shapeless, and easily overlooked.

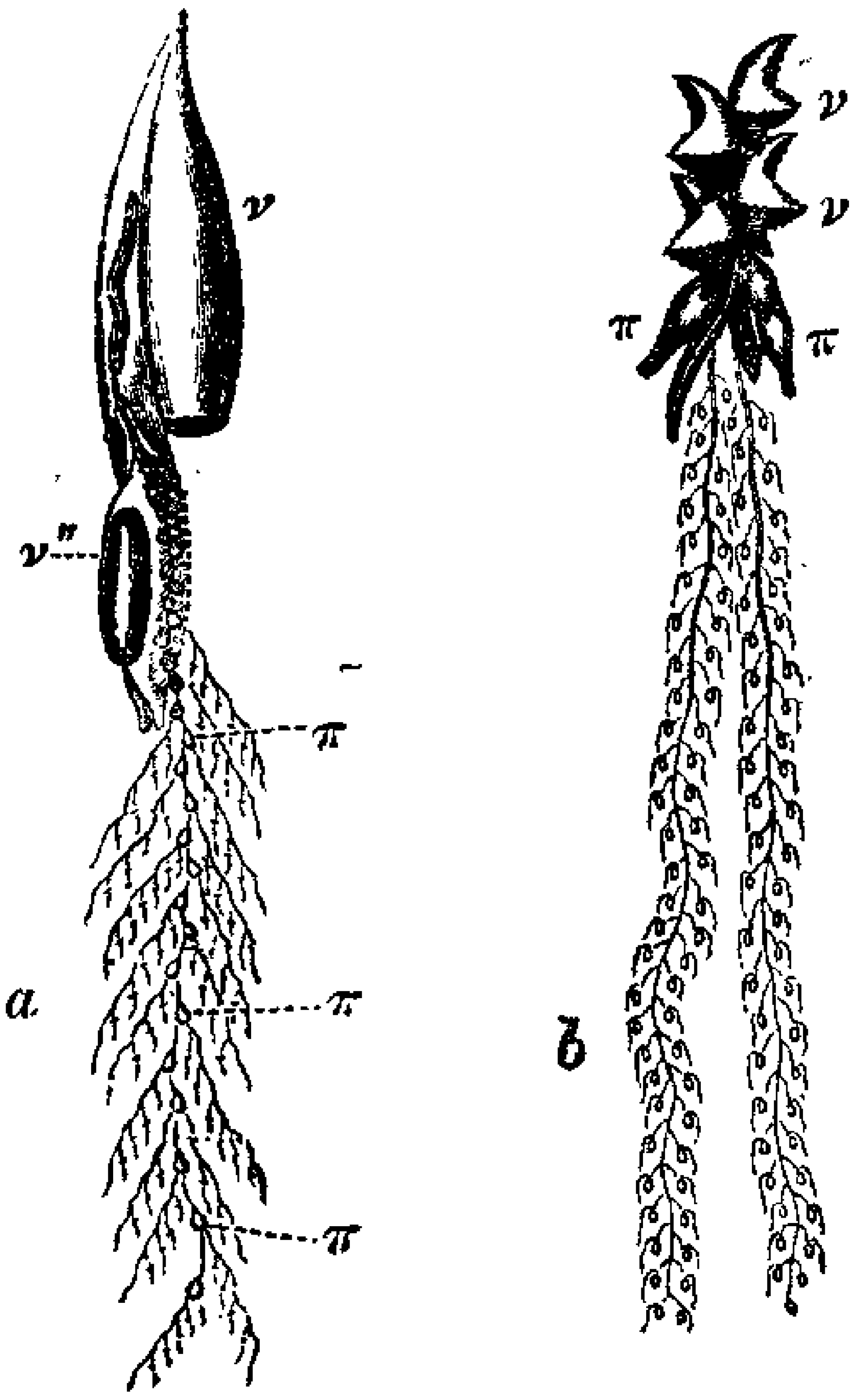


Lucernalia auricula.
(Natural size.)

"Their mode of progression," says Mr. Couch, "differs under different circumstances. If intending to move to any great distance, they do so by loosening their attachments, and then, by various and active contortions, they waft themselves away till they meet with any obstruction, where they rest; and if the situation suits them, they fix themselves; if not, they move on in the same manner to some other spot. If the change be only for a short distance, as from one part of a leaf to another, they bend their campanulate rims, and bring the tentacula in contact with the jaws, and by them adhere to it. The foot-stalk is then loosened and thrown forward and twirled about till it meets with a place to suit it; it is then fixed, and the tentacula are loosened, and in this way they move from one spot to another. Sometimes they advance like the Actiniæ, by a gliding motion of the stalk. In taking their prey, they remain fixed with their tentacula expanded, and if any minute substance comes in contact with any of the tufts, that tuft contracts, and is turned to the mouth, while the others remain expanded watching for prey."

The Calycophoridæ are distinguished by the cup-shaped swimming organs, which form the most prominent part of their body. Generally transparent like glass, their course upon distant inspection is only revealed by the bright tints of some of their appendages. In Diphyes, the type of the group, the two cups (ν, ν'') fit into each other so as to form a more or less perfect close canal. The common stem of the numerous polyp colony freely glides up and down the chamber thus formed, into which it can be completely retracted, and along its sides are placed the several appendages of the compound creature, consisting chiefly of polypites (π), tentacles, and

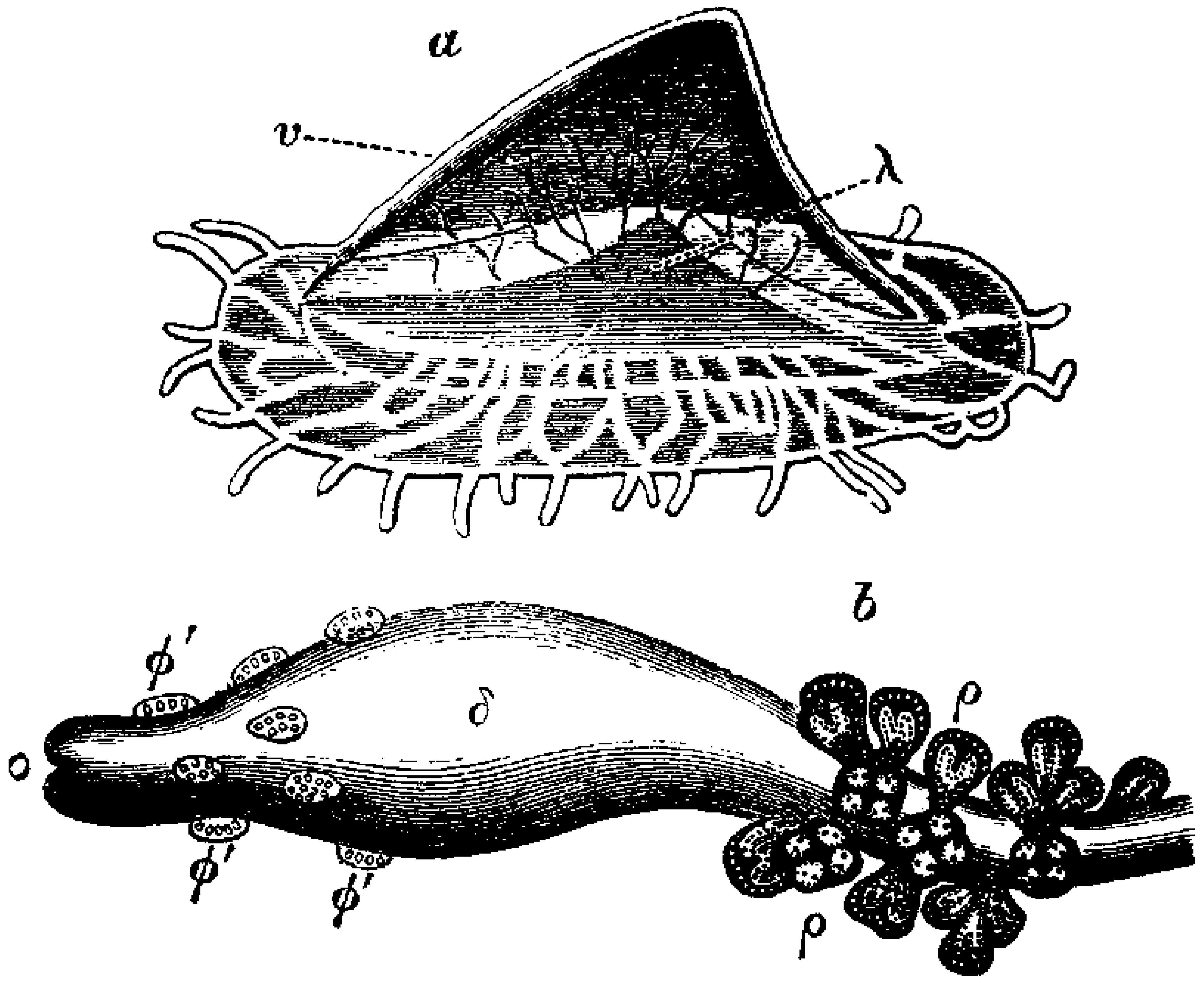
organs of reproduction. Large specimens of Diphyes attain, when fully extended, a length of several inches, the stem giving support to at least fifty different polypites. The other genera of the order exhibit a great variety in the form and arrangement of their various parts; thus, in Vogtia, each of the swimming organs (ν) is produced into five points, of which the three upper are much longer and stronger than the two lower. The individual polyps (π), large in size, but few in number, are congregated immediately under the swimming apparatus, and are provided with long and formidable tentacula.



a. Diphyes appendiculata. *b.* Vogtia pentacantha. (Natural size.)

In the Physophoridæ the basal end of the common polyp stem is modified so as to form a float or aëriform sac, which is, however, extremely different in shape, structure, and size in the various families. In the Velellæ, the float, whose under surface is studded, besides one larger central polypite, with numerous small nutritive, reproductive, and tentacular bodies, forms a horizontal disc traversed by a diagonal triangular crest, and divided into numerous hollow chambers. Thus equipped, the semi-transparent velella, beautifully tinged with ultramarine, sails on the surface of the warmer seas, but the currents of the Gulf Stream, and the westerly winds, frequently drift it to the coast of Ireland, where it is often found on the beach, entangled in masses of sea-weed. Of the vast numbers in which it sometimes occurs, Herr von Kittlitz relates an interesting instance in his "Travels to Russian America and Micronesia." "Having passed 30° N. lat. in the Pacific, the sea was suddenly found covered with myriads of Velellæ, of a size somewhat greater than the Atlantic species. Two days long the ship sailed through these floating masses, when suddenly the scene changed,

and large clusters of barnacles appeared, which, having no doubt devoured the soft parts of the Velellæ, now invested their horny skeletons. As the ship advanced, the number of the barnacle clusters augmented, which, to judge from the various sizes of the individuals, must have taken some time for their formation, and were apparently destined to increase until the final destruction of the Velellæ hosts, into which, from their greater weight, they were continually drifting deeper and deeper by the action of the currents. Again two or three days elapsed, and as the surface of the sea occupied by both species of animals extended at the least over four degrees of latitude,

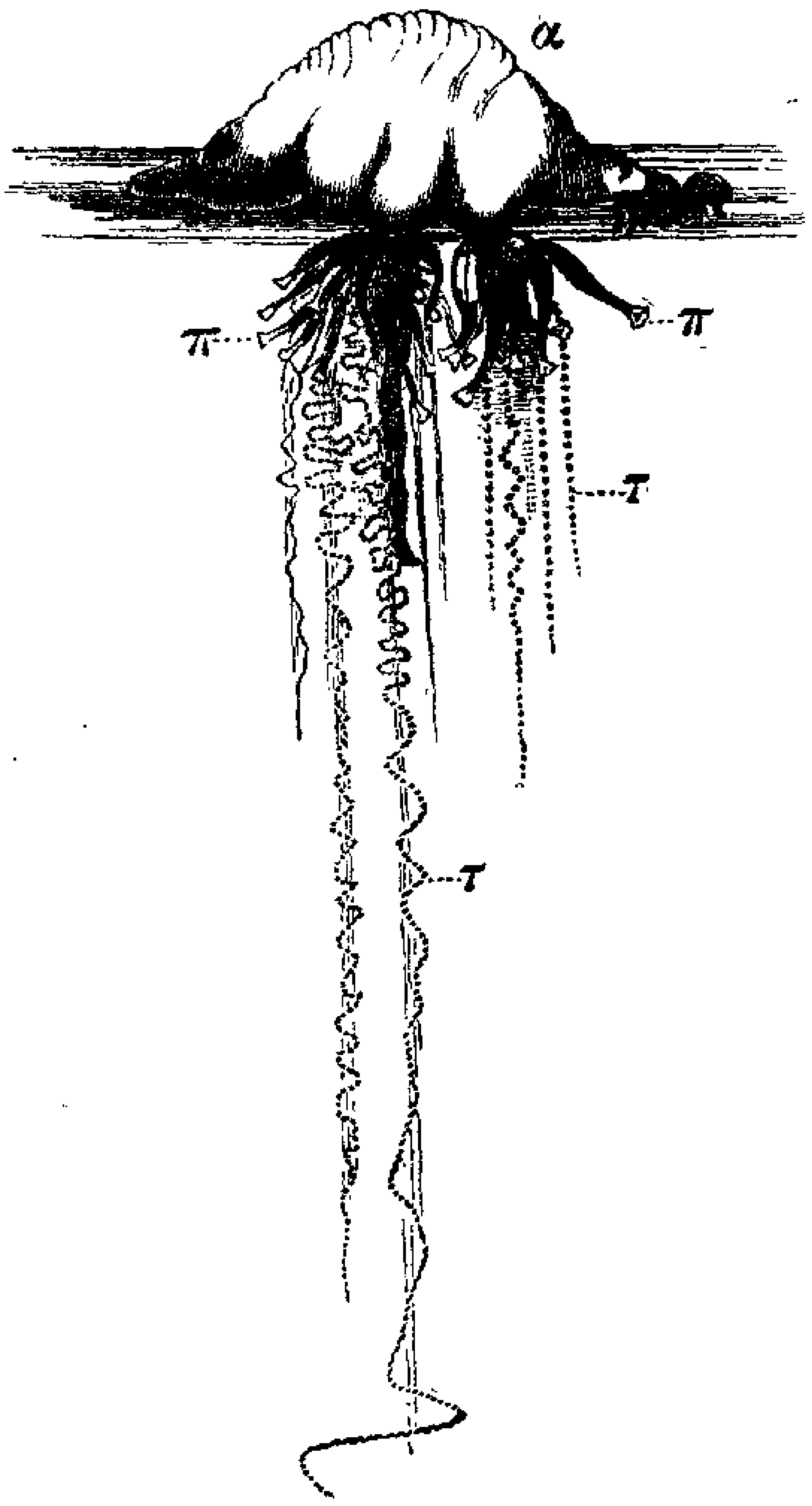


a. *Velella spirans*, somewhat enlarged.
b. One of its smaller polypites, much magnified. v. Crest. λ. Liver. o. Mouth of polypite. δ. Its digestive cavity. φ'. Rounded elevations, containing thread-cells. ρ. Medusiform zoöids.

a faint idea may be formed of their numbers. Shoals of dolphins and sperm-whales were busy exterminating the barnacles, as these had devoured the Velellæ. The whole scene was an example on the grandest scale of the destruction and regeneration perpetually going on in the wastes of the ocean.

The Physaliæ, which far surpass the Velellæ in size and beauty, are also inhabitants of the warmer seas, where the *Physalia caravella*, or "Portuguese man-of-war," is the mariner's admiration. On a large float-bladder eight or nine inches long and three inches broad, whose transparent crystal shines in every

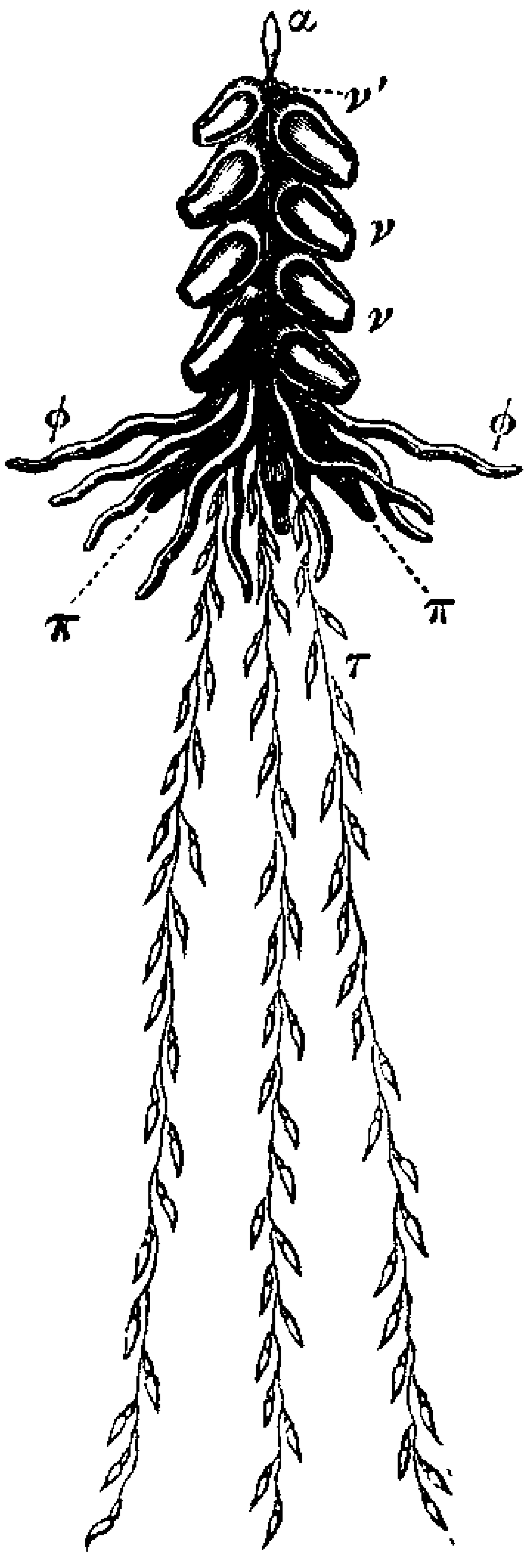
shade of purple and azure, rises a vertical comb, the upper border of which sparkles with fiery red. This beautiful float has a small opening at either end, and strong muscular walls, so that by their contraction its cavity can be considerably diminished. And thus partly by the escape of air forced out through the openings, and partly by the compression of what remains, the specific gravity is so much altered as to admit of the animal's sinking into the deep when danger threatens. Numerous polyps proceed from the lower surface, accompanied by tentacles having a sac-like extension at their base, and hanging down in beautifully blue and violet coloured locks or streamers. When fully extended, these tentacles form fishing lines fifteen or sixteen feet long, which, as their thread-cells are uncommonly large, at once paralyse the resistance of the fish or cephalopod they meet with. Then rolling together, they convey the senseless prey to the numerous mouths of the compound animal, which, sucking like leeches, pump out its nutritious juices. In this manner the greedy physalia devours many a bonito or flying-fish of a size far superior to its own, and such is the corrosive power of its tentacles that even man is punished with excruciating pains when heedlessly or ignorantly he comes within their reach. "One day," says Dutertre in his "History of the Antilles," "as I was sailing in a small boat, I saw a physalia, and as I was anxious to examine it more closely, I tried to get hold of it. But scarcely had I stretched out my hand when it was suddenly enveloped by a net of tentacles, and after the first impression of



Physalia caravella.—(Considerably reduced.)
α. Pneumatophore, or float-bladder. π. Polypites. τ. Tentacles.

cold (for the animal has a cold touch) it seemed as if my arm had been plunged up to the shoulder in a caldron of boiling oil, so that I screamed with pain." In his journey round the world, Dr. Meyen also relates the case of a sailor who jumped overboard to catch a physalia. But scarce had he come within reach of its tentacles when the excruciating pain almost deprived him of sensation, and he was with great difficulty hauled out of the water. A severe fever was the consequence, and his life was for some time despaired of.

Several of the Physophoridæ are provided, besides the float, with swimming-bells (*nectocalyces*) and peculiar appendages or bracteæ (*hydrophyllia*), which, overlapping the polypites, serve for their protection. The graceful *Athorybia rosacea* possesses from twenty to forty of these organs inserted in two or three circlets immediately below the pneumatocyst, and above a much smaller number of polypites.



Physophora Philippii.

α. Pneumatophore. ν. Swimming-bells. φ. Hydrocysts. π. Polypites. τ. Tentacles.

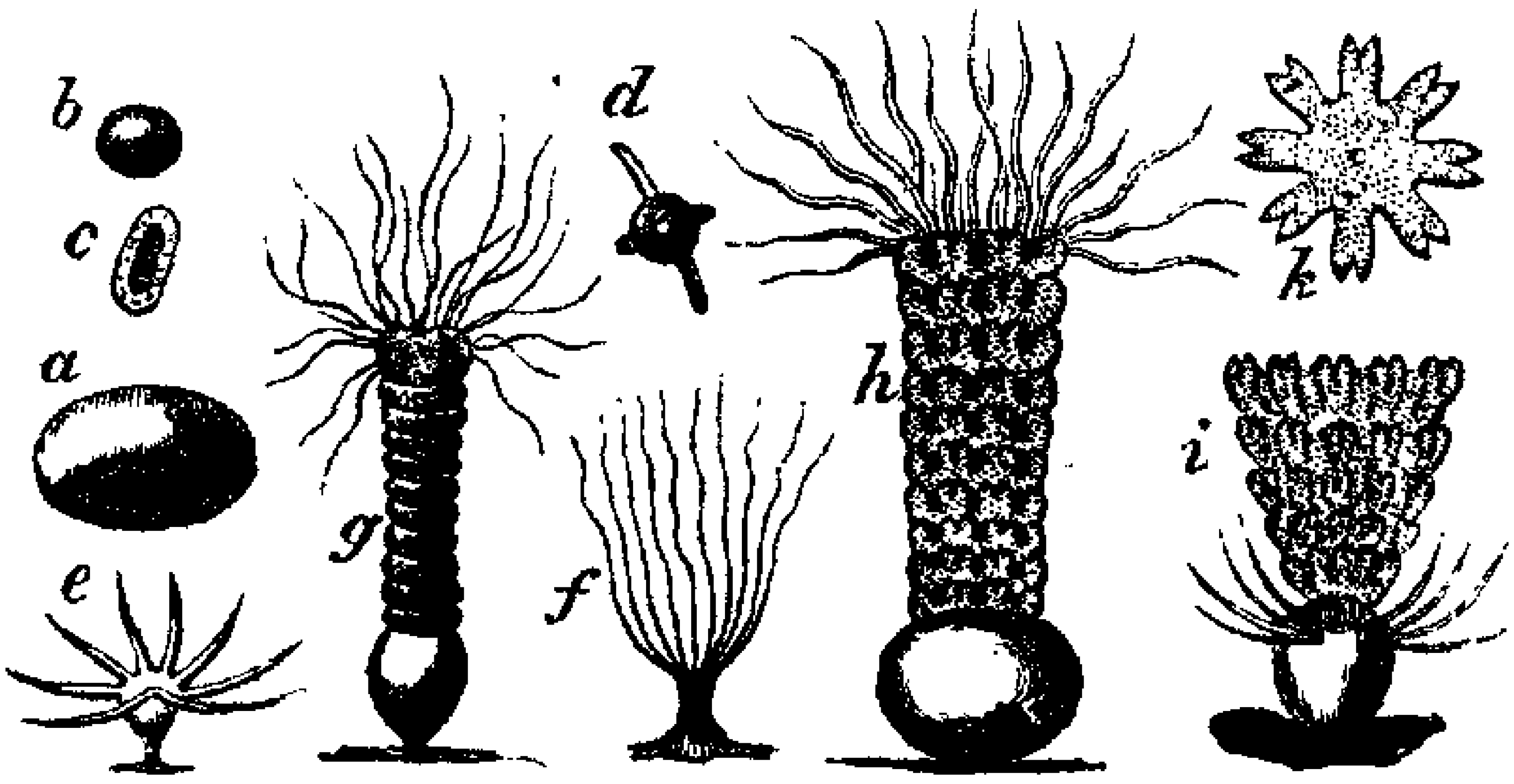
It has the power of alternately raising and depressing them so as to render them agents of propulsion.

The Physophoræ have no hydrophyllia, but their swimming-bells are considerably developed, and serve as powerful instruments of locomotion. They are also provided with certain processes termed "hydrocysts," which some observers appear disposed to regard as organs of touch. Such are but a few of the numerous genera of the Physo phoridæ.

Of the jelly-fishes in general it may be remarked that, though they are denizens of the frigid as well as of the temperate and tropical seas, their beauty increases on advancing towards the equator, for while the Medusæ in our latitudes are generally dull and obscure, those of the torrid zone appear in all the splendour of the azure, golden-yellow, or

ruby-red tints which distinguish the birds and fishes of those sunny regions. They are indeed of no immediate use to man, but their indirect services are not to be despised. They partly nourish the colossal whale, and thus, converted into oil, attract thousands of hardy seamen to the icy seas; numberless crustacea and molluscs also live upon their hosts, and are in their turn devoured by the mighty herring shoals, whose capture gives employment and wealth to whole nations of fishermen.

Armed with that wonderful instrument, the microscope, naturalists have been taught to disunite in many cases animals which from their external resemblance were formerly supposed to belong to the same class or family; and to join others to all appearances extremely dissimilar. Thus the Bryozoa have been detached from the polyps, in spite of their similitude of growth, while the roaming and fixed Hydrozoa have been found in many cases to be but alternating generations or various phases of development of the same animal. Take, for instance, *Chrysaora hysoscella* (see preceding figure, page 351), one of our commonest jelly-fishes. The ova this free-swimming creature produces might naturally be supposed to develop



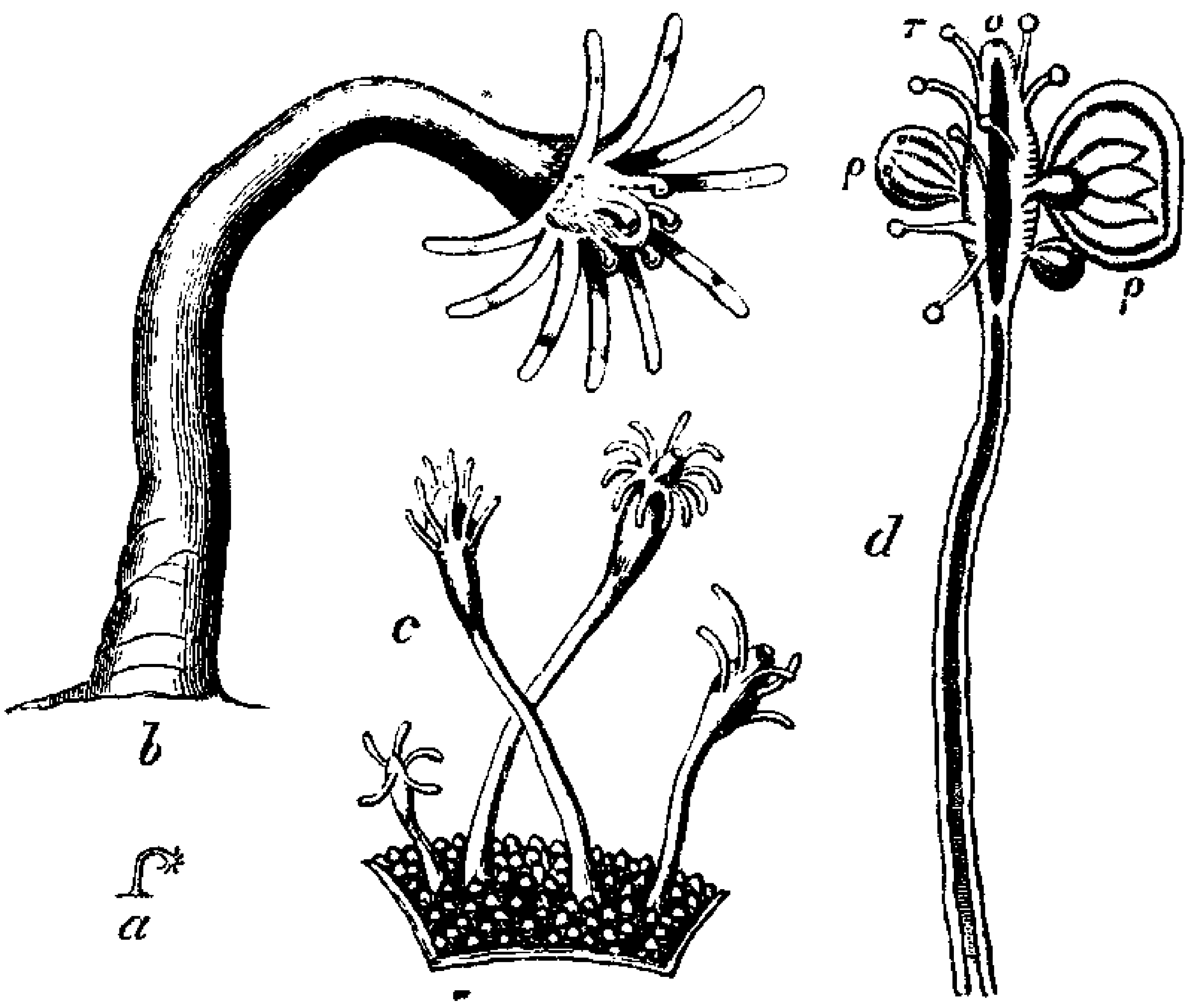
Development of Chrysaora hysoscella.

a. Ova with gelatinous investment. *b* and *c.* Free ova. *d.* Young Hydratuba developed therefrom. *e.* The same with eight tentacles. *f.* Hydratuba in its ordinary condition. *g, h.* More advanced forms, with constrictions. *i.* A specimen undergoing fission, in which the tentacles are seen to arise from below the constricted portion, while its upper segments separate and become free-swimming zoöids (*k*).

themselves into equally free-swimming Chrysaoræ; but instead of this they soon become attached, and grow into a colony of sessile Hydratubæ, as, at this stage of their career, they have been termed. For years they may thus continue, but then the evolutions shown in the annexed illustration take place until free-swimming zoöids are detached, which eventually become

similar to the huge Chrysaora, from one of whose ova the primitive hydratube was produced.

In a similar manner the Coryniadæ, a family of hydrozoic



Various forms of Coryniadæ.

a and b. *Vorticlava humilis.* c. Four polypites of *Hydractinia echinata*, growing on a piece of shell. d. Portion of *Syncoryne Sarsii*, with medusiform zoöids (ρ), budding from between the tentacles (τ) of the polypite (o).—(All, except a, magnified.)

polyps, which, unpossessed of the firm investment of the sertularians, are frequently found decking sea-weeds and stones with dense arborescent structures, give birth to detached medusiform zooids. On the other hand, many medusid forms produce organisms directly resembling their parents, and many fixed Hydrozoa, such as the Sertularidæ, do not give birth to free-swimming medusoids, but to ciliated gemmules, which, escaping from the capsules in which they had been formed, soon evolve themselves into true polyps. A great part of this "strange eventful history" is still enveloped in darkness, as the life of comparatively but few Hydrozoa has been thoroughly investigated; so much is certain that future observations will bring many new interesting relationships to light, and add new links to the chain which binds together the various members of the hydrozoic class.

Although the Ctenophora, thus named from the ciliated bands which constitute so obvious a feature in their physiognomy, closely resemble the Medusæ by their gelatinous consistence and their mode of life, yet a more complex organisation assigns them the

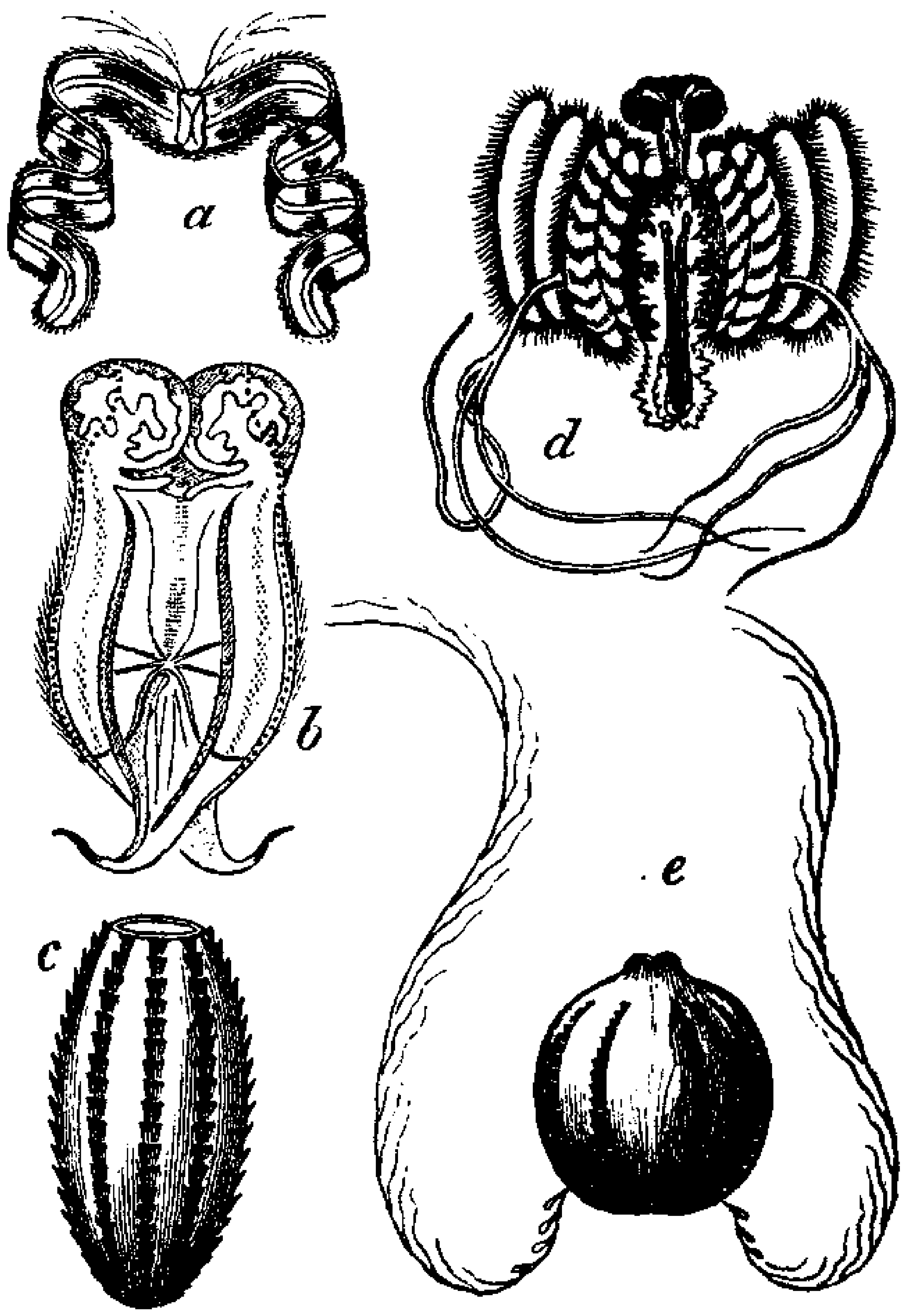
highest rank among the Actinozoa, and approximates them to the sea-anemones. The elegant *Pleurobrachia pileus*, which in the summer so often appears on our coasts in countless multitudes, is the species that has been longest known. The melon-shaped body, from half an inch to nearly an inch in length, is clear as crystal, and divided by eight longitudinal equidistant ribs into eight equally large segments or fields. These ribs are covered with numberless flat paddles or ciliæ, placed one above another, and obeying the will of the animal. When it wishes to swim backwards or forwards, it sets all its paddles in motion, whose united power drives the living crystal rapidly and gracefully through the water; and when it wishes to turn, it merely stops their movements on one side. In sunlight, the ribs of the pleurobrachia sparkle with all the colours of the rainbow; in darkness they emit a beautiful cerulean phosphorescence.

The prehensile apparatus of the elegant little creature is no less beautifully organised than its locomotive mechanism. It consists of two long tentacles emerging from the under part of the body, and capable of so wonderful a contraction as entirely to disappear within its cavity, where they are lodged in tubular sheaths. On one side they are provided at regular intervals with shorter and much thinner filaments, which roll together spirally when the chief tentacle contracts, and expand when it is stretched forth. On the secondary branches themselves still more minute threads are said to have been observed. Words are unable to express the beauty which the entire apparatus presents in the living animal, or the marvellous ease with which it can be alternately contracted, extended, and bent at an infinite variety of angles.

Most of the Ctenophora are spheroidal or ovate, but in Cestum elongation takes place to an extraordinary extent, at right angles to the direction of the digestive track, a flat ribbon-shaped body, three or four feet in length, being the result. The Callianiræ are remarkable for having their ciliated ribs elevated on prominent wing-like appendages, and the Beroës, which have no tentacles, receive their nourishment through a widely gaping mouth, whose size makes them amends for the deficiency of other prehensile organs. Such are but a few of the varieties exhibited by the beautiful and interesting Ctenophora.

In habit they resemble the oceanic Hydrozoa, like them

swimming near the surface in calm weather, and again descending on the approach of a squall. Like them also, their delicate structures rapidly disappear when removed from the sea-water and exposed to the rays of the sun, an almost imperceptible film remaining the only trace of what was erewhile an active and beautiful organism. Yet in spite of their aqueous consistence the Ctenophora are very voracious, feeding on a number of



Various forms of Ctenophora.

a. Cestum Veneris. b. Eurhamphæa vexilligera. c. Beroë rufescens. d. Callianira triploptera. e. Pleurobrachia pileus.—(*a* is considerably reduced; *b* slightly so; *c* and *e* are about the natural size; the size of *d* is uncertain.)

floating marine animals, among which their own kindred seem especially to be preferred. The prey once swallowed is assimilated with a rapidity which to some may seem strange when the simple structure of the digestive apparatus is considered.

The land has its flowers; they bloom in our gardens, they adorn our meadows, they perfume the skirts of the forest, they brave the winds that blow round the high mountain peaks, they conceal themselves in the clefts of rocks, or spring forth

out of ruins; wherever a plant can find room there Flora appears with her lovely gifts.

But the ocean also has its large radiate anemones, whose lustrous petals, still more wonderful than those of the land, for they are endowed with animal life, form the chief ornament of the crystal tide-pools, or of the sheltered basins of our rock-bound shores.

More than twenty species of these marine flowers, many of them displaying a gorgeous wreath of richly coloured tentacles, are denizens of the British waters; but the finest and largest are found along the margin of the equatorial ocean, where they occasionally measure a foot in diameter. Their tints are as various as the arrangement of their prehensile crown; fiery red and apple-green, yellow and white as driven snow. Sometimes the tentacles form a gorgon's head of long thick worms, clothed in satin and velvet, and sometimes a thicket of delicate filaments.

Nothing seems more inoffensive than a sea-anemone expanding its disc in the tranquil waters, but woe to the wandering annelide, to the shrimp, or whelk, or nimble entomostracon, that comes within reach of its urticating tentacles, for, plunged into a fatal lethargy, it is soon hurried to the gaping mouth of its voracious enemy, ever ready to engulf it in a living tomb. The morsel thus swallowed is retained in the stomach for ten or twelve hours, when the undigested remains are regurgitated, enveloped in a glairy fluid, not unlike the white of an egg. The size of the prey is frequently in unseemly disproportion to the preyer, being often equal in bulk to itself. Thus Dr. Johnstone mentions a specimen of *Actinia crassicornis*, that might have been originally two inches in diameter, and that had somehow contrived to swallow a scallop-valve of the size of an ordinary saucer. The shell fixed within the stomach was so placed as to divide it completely into two halves, so that the body, stretched tensely over, had become thin and flattened like a pancake. All communication between the inferior portion of the stomach and the mouth was of course prevented; yet instead of emaciating and dying of an atrophy, the animal had availed itself of what undoubtedly had been a very untoward accident to increase its enjoyments and chances of double fare. A new mouth, furnished with two rows of numerous tentacula, was

opened upon what had been the base, and led to the under stomach; the individual had indeed become a sort of Siamese twin, but with greater intimacy and extent in its unions.

From this instance we may naturally infer that the Actiniæ are no mean adepts in the art of accommodating themselves to circumstances. They may be kept without food for upwards of a year; they may be immersed in water hot enough to blister their skins, or exposed to the frost, or placed within the exhausted receiver of the air-pump, and their hardy vital principle will triumph over all these ordeals. Their reproductive powers are truly astonishing. Cut off their tentacles, and new ones sprout forth; repeat the operation, and they germinate again. Divide their bodies transversely or perpendicularly through the middle, and each half will develop itself into a more or less perfect individual.

But these apparently indestructible creatures die almost instantly when plunged into fresh water, which is for them, or for so many other marine animals, a poison no less fatal than prussic acid to man.

Though generally firmly attached by means of a glutinous secretion from their enlarged base to rocks, shells, and other extraneous bodies, the sea-anemones can leave their hold, and remove to another station, whensoever it pleases them, either by gliding along with a slow and almost inperceptible movement or by reversing the body and using the tentacula as feet; or, lastly, inflating the body with water so as to diminish its specific weight, they detach themselves, and are driven to a distance by the random motion of the waves. They are extremely sensible not only to external irritations—the slightest touch causing them to shrink into a shrivelled shapeless mass—but also of atmospherical changes. They hide their crown under a glare of light; but in a calm and unclouded sky expand and disclose every beauty, while they remain contracted and veiled in cloudy or stormy weather. The Abbé Dicquemare has even found, from several experiments, that they foretell changes of the weather as certainly as the barometer. When they remain naturally closed there is reason to fear a storm, high winds, and a troubled sea; but a fair and calm season is to be anticipated when they lie relaxed with expanded tentacula. The ova of the Actiniæ are detained for some time after their sepa-

ration in the interseptal spaces, or even in the stomach, and there hatched, as it were, into their lasting form. On emerging into the open ocean, they already resemble their full-grown relatives, the only difference consisting in a smaller number of tentacles and septa. The sea-anemones were consequently supposed to be viviparous, an error which more accurate observations have fully refuted.

Both the Ctenophora and the Sea-Anemones are single or solitary, but the vast majority of the Actinozoa consist of aggregated animals attached to one another by lateral appen-

Alcyonidium elegans.

a. Branch to which the polypary is fixed. b. Foot. c. Trunk. d. Polyp-bearing branches. e. Polyps contracted within the foot.

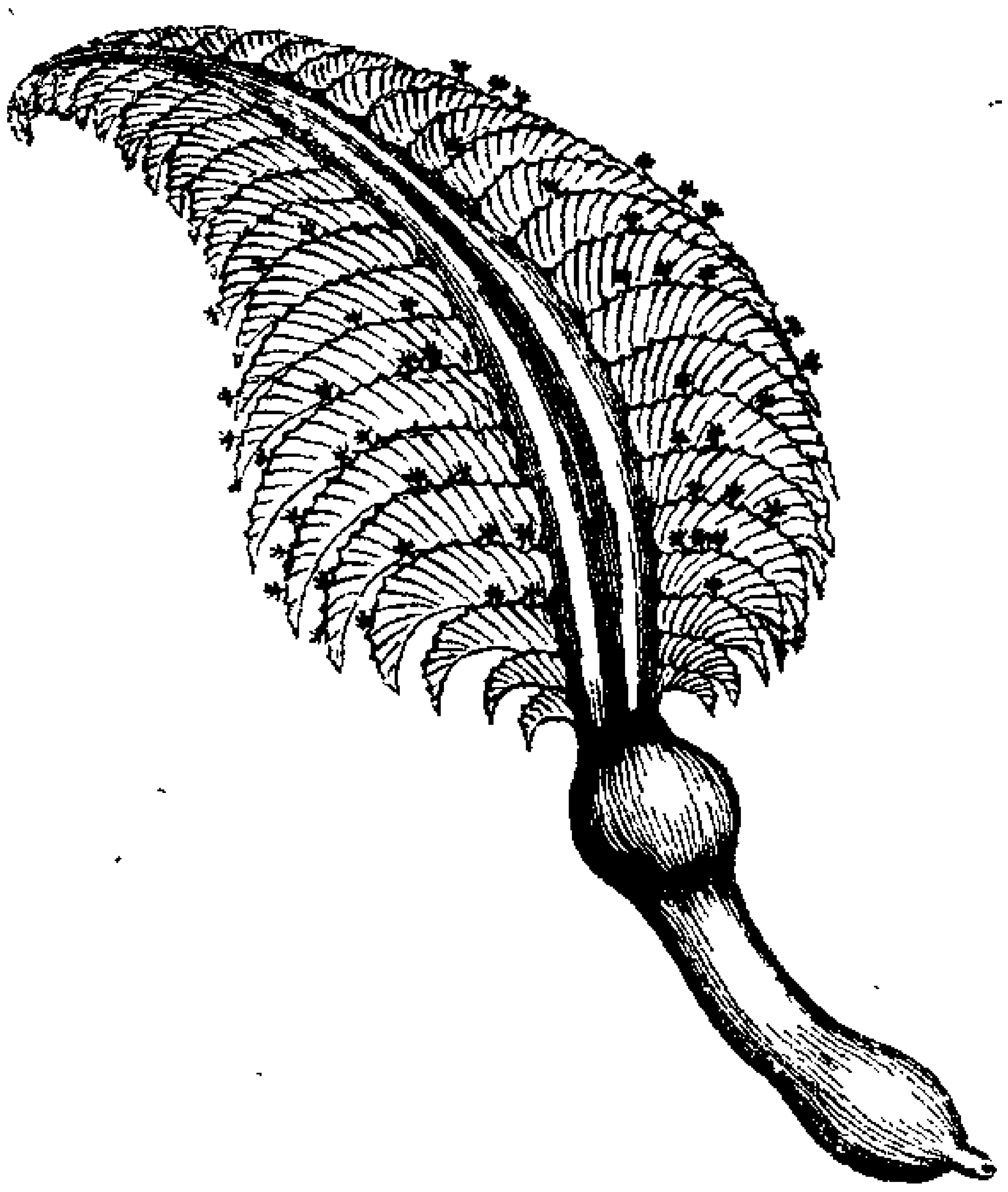
dages, or by their posterior extremity, and participating in a common life, while at the same time each member of the family enjoys its independent and individual existence. These compound polyps are all either *Alcyonarians*, in which each polyp is furnished with eight pinnately fringed tentacles, or *Zoantharians*, in which the tentacula are simple or variously modified, and generally disposed in multiples of five or six. The Alcyonarians are again subdivided into the four families of the Alcyonidæ, the Pennatulidæ, the Gorgonidæ, and the Tubiporidæ.

The Alcyonidæ vary much in form, being either lobed,

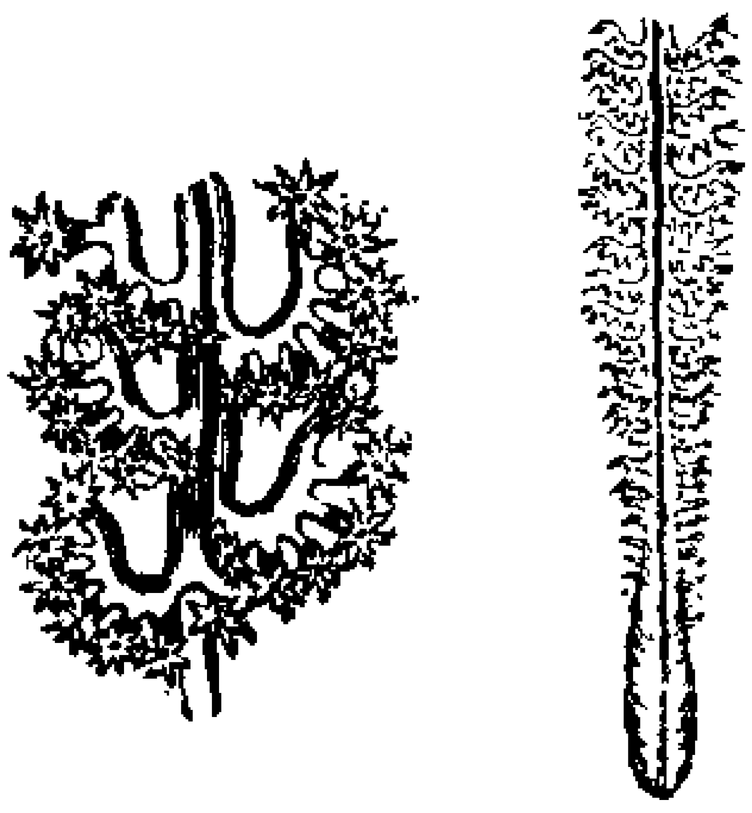
branched, rounded, or existing in a shapeless mass or crust, while the interior substance is of a spongy or cork-like nature, surrounded by tubular rays enclosed in a sort of tough fleshy membrane. The *Alcyonium digitatum* is one of our most common marine productions, so that on many parts of the coast scarce a shell or stone can be dredged from the deep that does not support one or more specimens. As it lies on the shore, it certainly offers few inducements from its beauty to recommend it to further notice, and seems fully to warrant the more expressive than elegant names of "cow's paps," "dead man's toes," or "dead man's hands," which the fishermen have conferred on it. On putting one of these shapeless masses into a glass of sea-water, however, and allowing it to remain for a little time undisturbed, its real nature becomes apparent, and a series of most interesting phenomena present themselves. The dull orange mass, which was at first opaque and of a dense texture, slowly swells and becomes more diaphanous, apparently by the absorption of the surrounding water into its substance, until, having attained its full dimensions, numerous dimples appear, studding its entire surface, each of which, as it gradually expands, reveals itself to be a cell, the residence of a polyp, which, gradually protruding itself, pushes out a cylindrical body, clear as crystal, fluted like a column, and terminated by a coronet of eight delicately fringed tentacula. The unsightly aspect of the trunk, which reminded us of cadaverous fingers or toes, is now forgotten, just as we forget the uncouth branches of a cactus when we see it clothed with its gorgeous flowers. All the polyp-cells are connected by a complicated system of inosculating canals, bound together by a fibrous net-work, and lying imbedded in a transparent jelly, which forms the fleshy part of the compound animal. The eggs are lodged in the tubes, and at length discharged through the mouth.

The Sea-Pens, or Pennatulæ, are remarkable from the circumstance that, although they possess an internal calcareous support, they are not permanently attached to foreign bodies. The lower portion of the stem, which strikingly resembles the barrel of a quill, is naked, and, when found in the bays upon our coast, is generally stuck into the mud at the bottom like a pen into an inkstand, whilst the upper two thirds of the stem are feathered with long closely set pinnæ, comparable to the

barbs of a quill, from the margin of which are protruded the rows of polyps which minister to the support of the common body of the compound animal. The purple-red *Pennatula phosphorea*, which is found in great plenty sticking to the baits on the fishermen's lines, especially when they use muscles to bait their hooks, is one of the most singular and elegant of the British sea-pens. Some authors believe that it is capable of using its fin-like arms like oars, but observations are wanting in corroboration. The pale orange fawn *Virgularia mirabilis*, an allied species, has a more elongated slender form than the pennatula. Its rod-like body, from six to ten inches long, is furnished with short fin-like lobes of a crescent shape, which approach in pairs, but are not strictly opposite; they are about the eighth of an inch asunder, and are furnished along the margins with a row of urn-shaped polyp-cells. These very delicate and brittle animals seem to be confined to a small circumscribed part of the coast, which has a considerable depth and a muddy bottom, and the fishermen accustomed to dredge at that place believe from the cleanness of the Virgulariæ, when brought to the surface, that they stand erect at the bottom with one end fixed in the mud or clay.



Grey Sea-Pen.



Virgularia mirabilis.

The Gorgonidæ (Gorgonia, Primnoa, Corallium, Isis, Mopsea) mainly differ from the Alcyonidæ in having an erect and branching stem, firmly rooted by its expanded base. A soft and fleshy crust, studded with numerous polyps, envelops a solid horny or calcareous axis, which serves as a support to the

arborescent structure, and enables it to rise to a height of several feet, or even, if we are to credit the Norway fishermen, to rival our forest-trees in magnitude. This they conclude to be the case from their nets being sometimes entangled on the trunk or stem of the *Primnoa lepadifera*, as this large species of gorgon is called, when the united strength of several men is unable to free the nets. "They have even assured me," says Sir A. Capell de Brooke, "that the corals grow to the height of fifty or sixty feet, as they judge from the following circumstance, which seems clear and simple. The lines for the red-fish, which is found in the greatest plenty where the primnoa grows, are set in very deep water at the distance of about six feet from the bottom, and in the parts where it is flat and level, which they can tell from their soundings. On drawing up the lines at the distance of forty, fifty, or sixty feet, and sometimes even more from the bottom, they get entangled with some of the upper parts or branches of the gorgon, which are thus torn off, and hence they reasonably conclude that the animal rises to this height."

The Gorgonidæ either branch away irregularly like shrubs, or else their branches inosculate and form a kind of net or fan, as in the *Flabellum Veneris*, a beautiful Indian species, which some naturalist of more than usual fancy has appropriated to the use of Venus.

Four British species of Gorgonia are recorded. *G. verrucosa*, the commonest of these, abounds in deep water along the whole of the south coast of England. It is more than twelve inches in height, and fifteen or seventeen in breadth, and expands laterally in numerous cylindrical and warty branches. It is somewhat fan-shaped, but does not form a continuous network. Its coral has a dense black axis, with a snow-white pith in the centre, and is covered, while living, with a flesh-coloured crust. The flexible corneous stem of the Gorgonias enables them to bend beneath the passing current, and thus prevents their long and slender ramifications from breaking, while the hard calcareous branches of the valuable red coral (*Corallium nobile*) are sufficiently short and strong to resist the violence of the sea. This beautiful marine production, though also occurring in the Ethiopic Ocean and about Cape Negro, is chiefly found in the Mediterranean, on the shores of Provence,

about the isles of Majorca and Minorca, on the south of Sicily, and on the coast of Africa. It grows on rocky bottoms, and frequently in an inverted position, or downwards from the under surface of stones, generally at a depth of several hundred feet.

When alive, the soft rind which invests the valuable central stony axis is studded with snow-white polyps. The fishery is

Red Coral.
Gorgonia nobilis. (A small detached portion magnified.)

still carried on in the same way as it was described by Marsigli 150 years ago. The net is composed of two strong rafters of wood tied crosswise, with leads fixed to them; to these they fasten a quantity of hemp twisted loosely round and intermingled with some loose netting. This apparatus is let down, and while the boat is sailing or being rowed along, alternately raised and dropped so as to sweep a certain extent of the bottom

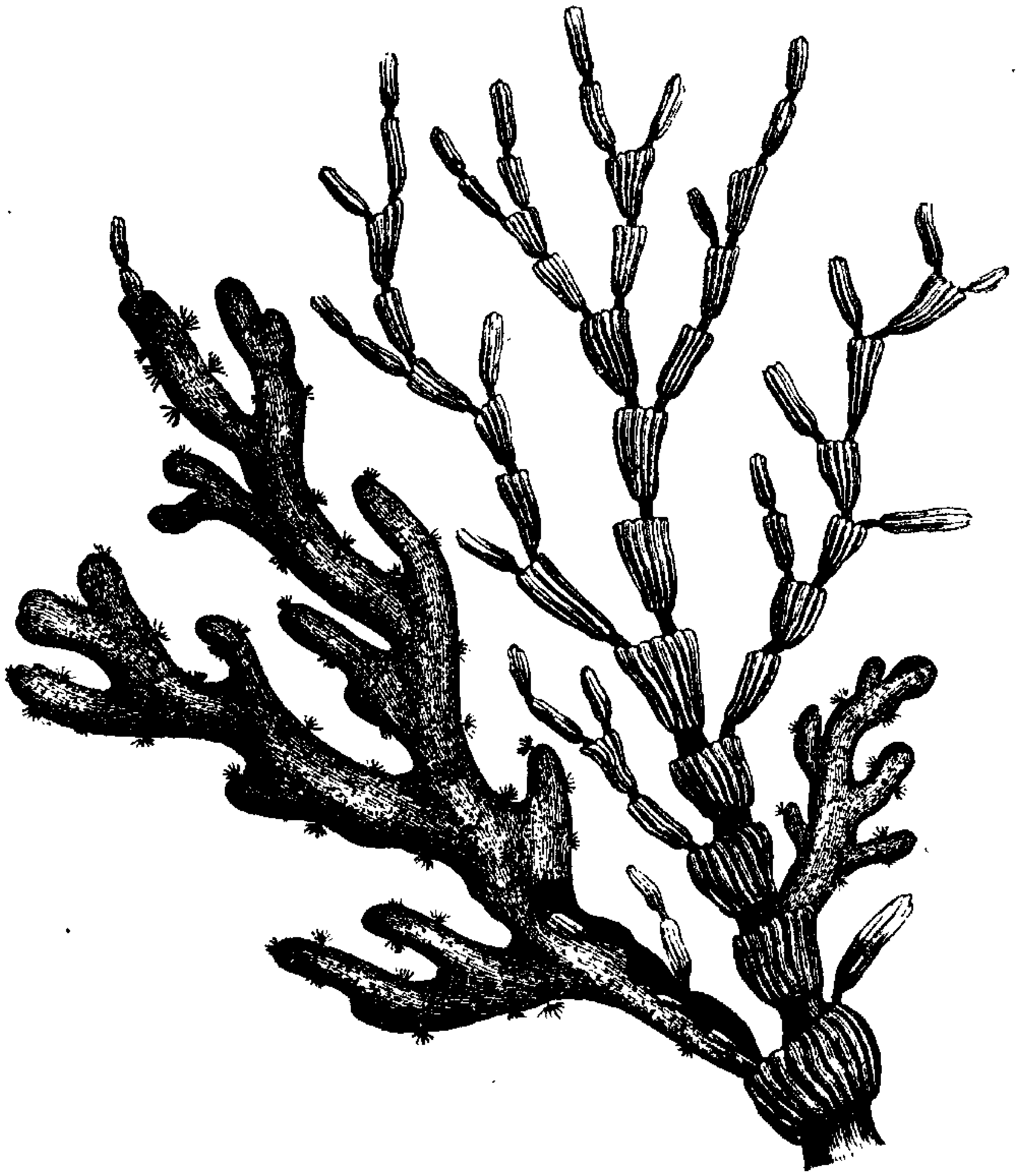
and to entangle the corals in its coarse meshes. The labour, as may be imagined, is very great; frequently, after a long toil, the net is brought up empty, or filled only with other marine productions, which, however interesting they may be to the naturalist, are perfectly worthless in the eyes of the coral-fisher; and not seldom immense exertions are required to loosen it from the rocks, among which it has got entangled.

The chief seat of the coral-fishery is at present along the coasts of Algeria and Tunis, where it is almost exclusively carried on by the Italians, who fit out more than 400 small ships, or "corallines," of from five to sixteen tons, for this purpose. In spring this fleet of nut-shells leaves the ports of Torre del Greco, Sicily, Sardinia, and Genoa, and proceeds to its various points of destination, where it remains until the autumnal gales compel the fragile "corallines" to retire. Every month or fortnight the products of the fishery are delivered up to agents in Bona or La Calle, under whose direction the corals are sorted, packed in cases, and sent to Naples, Leghorn, or Genoa, where they are cut, polished, and manufactured into necklaces and other ornaments or trinkets. About 4,000 sailors are employed in the fishery, each man receiving an average pay of 380 franks for the season, which he almost entirely brings home with him, his trifling expenses on land being generally defrayed by the small pieces of coral he manages to conceal from the sharp eye of the "padrone." The average quantity of corals fished by each "coralline" amounts to about six hundredweight, and the total value of the fishery to more than 200,000*l.*, without taking into account the produce of the fisheries at Stromboli, in the Straits of Messina, and other parts of the Italian coast.

The manufactured articles sell of course for a much higher price, so that the "red coral" is a by no means inconsiderable article of trade. Great quantities are exported to India, and in Leghorn and Genoa several large manufactories work exclusively for that distant market, where the blood-red corals, whose colour harmonises with the dark complexion of the native ladies, are particularly in demand, while those of a roseate hue are preferred in Europe.

The fishermen have a strange belief that the corals are by nature soft, but immediately turn into stone from terror when

entangled by the net. There is also a legendary tale of an enchanted coral-tree, large and powerful as an oak, which is said to grow in a deep grotto at the foot of Mont Alban, on the Ligurian coast. It extends its arms when no danger is nigh, but immediately withdraws them, like a cuttle-fish, at the approach of an insidious enemy. This superstition is so firmly



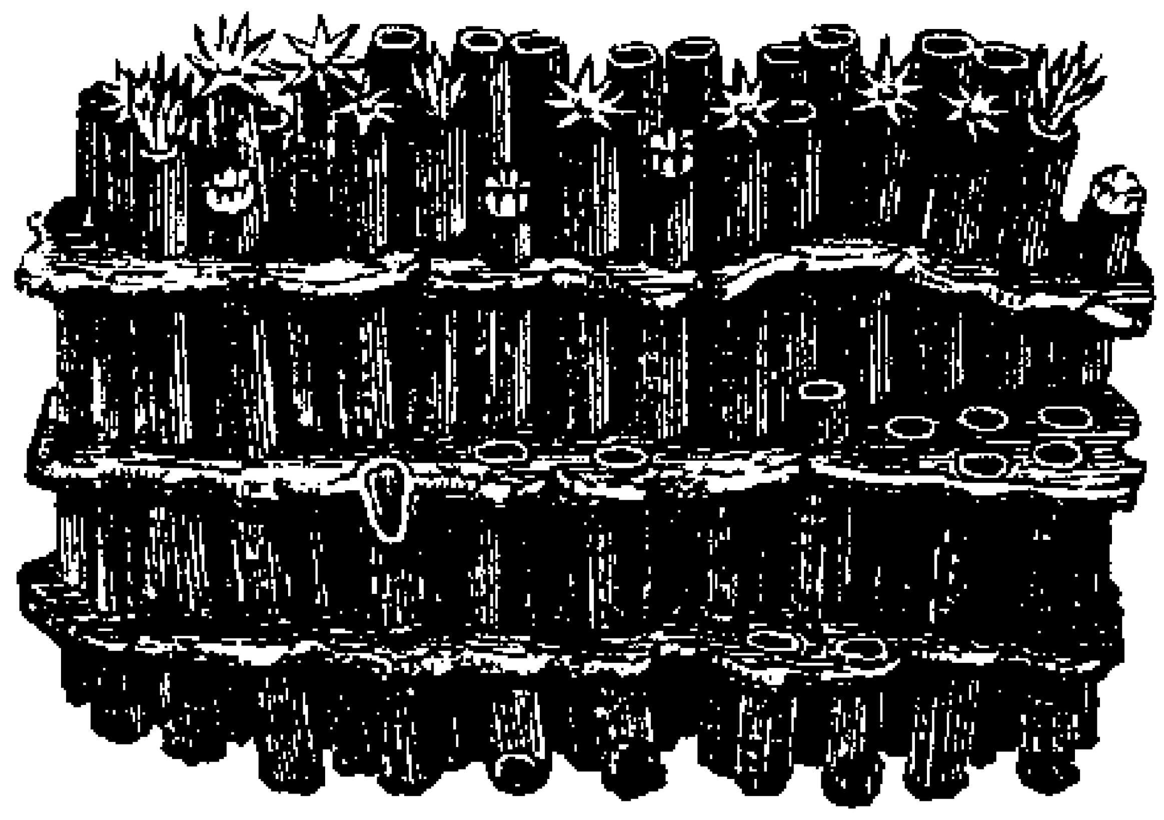
Isis hippuris.

rooted that, while Professor Vogt was at Villafranca in 1865, a "coralline" arrived from Torre del Greco for the purpose of fishing for this imaginary prey. The "padrone" swore he would not leave the neighbourhood before he had secured his prize, hoping to enrich himself with the spoils, but doomed, no doubt, to a grievous disappointment, and a considerable loss, on a coast where but few ordinary corals are found.

In the elegant *Isis hippuris*, which grows in the Indian Ocean,

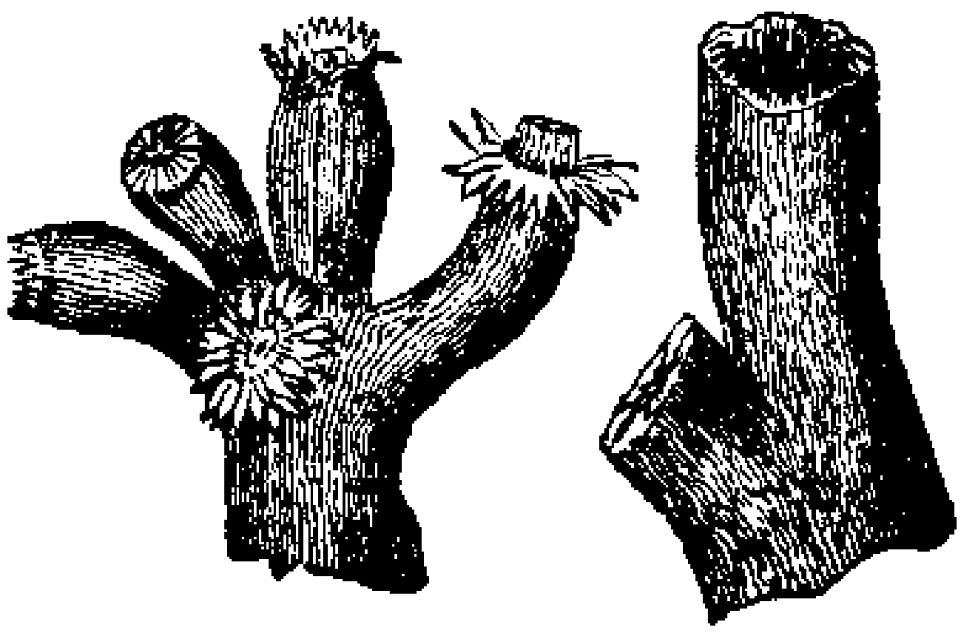
and is frequently found in cabinets of natural history, the horny and calcareous matter of the axis is disposed in alternate joints, so as to unite flexibility with firmness. A similar structure of alternately disposed calcareous and horny segments occurs in Mopsea. In Isis branches are developed from the calcareous, in Mopsea from the horny segments of the axis.

The Tubiporidæ are confined to the narrow limits of a single genus containing but few species. Here the polypary is composed of distinct calcareous tubes rising from a fleshy or membranaceous basis, and arranged in successive stages. These tubes are separated from each other by considerable intervals, but mutually support each other by the interposition of external horizontal plates, formed of the same dense substance as themselves, by which they are united together, so that a mass of these tubes exhibits an arrangement something like that of the pipes in an organ, whence the beautiful Indian species, *Tubipora musica*, has derived its name. From the upper ends of the tubes the polyps are protruded, and being, when alive, of a bright grass-green colour, they contrast very beautifully with the rich crimson of the tubes they inhabit.



Tubipora Musica.

In our seas, the coralligenous Zoophytarians, distinguished by the hard calcareous skeletons they deposit within their tissues are but feebly represented by a few straggling Caryophylliæ, but in the tropical ocean they branch out into numerous families, genera, and species, and play a highly important part in the economy of the maritime domain. Originally proceeding from single ova, which at first freely move by means of vibratile ciliæ, and become fixed after a short period of erratic existence, they multiply by gemmation, and grow into an immense variety of forms, of which the following description by one who has long and attentively studied them in their native haunts may serve to give an idea. "Trees of coral,"



Caryophyllia.

says Professor Dana, "are well known; and although not emulating in size the oaks of our forests—for they do not exceed six or eight feet in height—they are gracefully branched, and the whole surface blooms with coral polyps in place of leaves and flowers. Shrubbery, tufts of rushes, beds of pinks, and feathery mosses, are most exactly imitated. Many species spread out in broad leaves or folia, and resemble some large-leaved plant just unfolding; when alive, the surface of each leaf is covered with polyp-flowers. The cactus, the lichen clinging to the rock, and the fungus in all its varieties, have their numerous representatives. Besides these forms imitating vegetation, there are gracefully modelled vases, some of which are three or four feet in diameter, made up of a network of branches and branchlets, and sprigs of flowers. There are also solid coral hemispheres like domes among the vases and shrubbery, occasionally ten or even twenty feet in diameter, whose symmetrical surface is gorgeously decked with polyp-stars of purple and emerald-green."

Under such aspects appear the living organisms whose combined efforts have mainly constructed those reefs and islands of coral origin which now lie scattered far and wide over the surface of the equatorial ocean. Words are inadequate to express the splendour of the submarine gardens with which the lithophytes clothe the rocky shores of the tropical seas.

"There are few things more beautiful to look at," says Captain Basil Hall, "than these corallines when viewed through two or three fathoms of clear and still water. It is hardly an exaggeration to assert that the colours of the rainbow are put to shame on a bright sunny day by what meets the view on looking into the sea in those fairy regions." And Ehrenberg was so struck with the magnificent spectacle presented by the living polyparia in the Red Sea that he exclaimed with enthusiasm, "Where is the paradise of flowers that can rival, in variety and beauty, these living wonders of the ocean!"

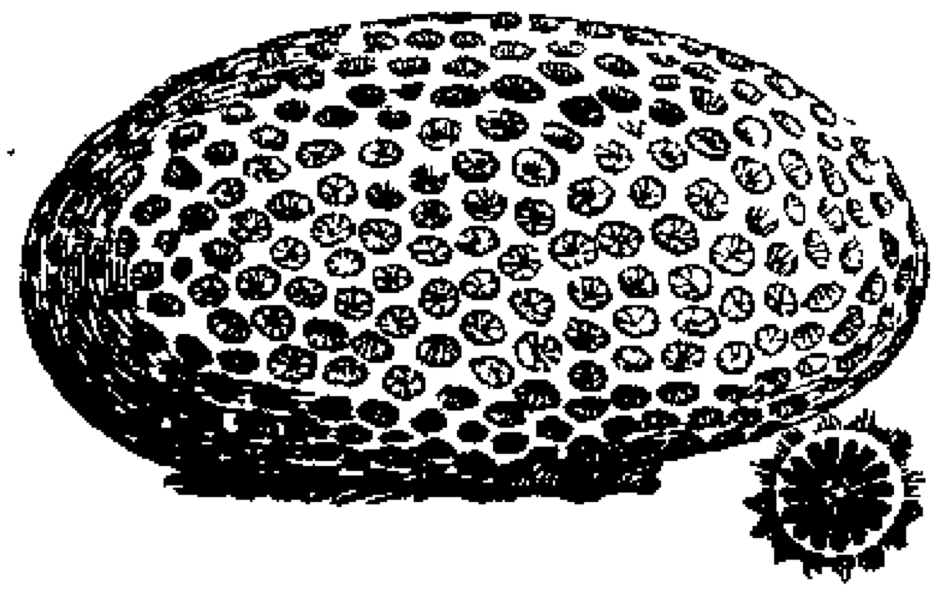
Besides the charms of their own growth, the tropical coral gardens afford a refuge or a dwelling-place to numberless animals clothed in gorgeous apparel. Fishes attired in azure, scarlet, and gold, crustaceans, sea-urchins, sea-stars, sea anemones, annelides, of a brilliancy of colour unknown in the northern seas, glide or swim along through their tangled

shrubberies; and frequently the gigantic tridacna, embedded in their calcareous parterres, discloses, on opening her ponderous valves, her violet mantle tinted with emerald-green. The enchanted naturalist lingers for hours over the magnificent spectacle, and forgets the lapse of time, as wonders upon wonders crowd on his enraptured gaze.

But the tropical coral-gardens serve not only as a harbour of refuge to the numberless creatures that frequent their labyrinthine recesses, for many annelides, crustaceans, asterias, and even fishes, feed upon their animal flowrets. Among these, the Scari are provided with a very remarkable dental apparatus to protect their mandibles from injury while biting the calcareous corals. These fishes have their jaws, which resemble the beak of a parrot (whence they receive their usual appellation "parrot fishes"), covered externally with a kind of pavement of teeth, answering the same purpose as the horny investment of the mandibles of the bird. The teeth that form this pavement are perpetually in progress of development towards the base of the jaw, whence they advance forward, when completed, to replace those which become worn away in front by the constant attrition to which they are subjected. Thus armed, the Scari browse without difficulty on the newest layers of the stony corals, digesting the animal matter therein contained, and setting free the carbonate of lime in a chalky state. Many of the Diodons, Chætodons, and Balistæ or file-fishes, of which Kittlitz saw some new species, one still more splendid than the other, in every lagoon-island he visited in the long range of the Carolines, likewise feed upon corals, and possess a dental apparatus fit for masticating their refractory aliment. The Diodons have grooved teeth, excellently adapted to crush and bruise, and the Balistæ have eight strong conical teeth in every jaw, with which they easily nip off the shoots of the coral bushes.

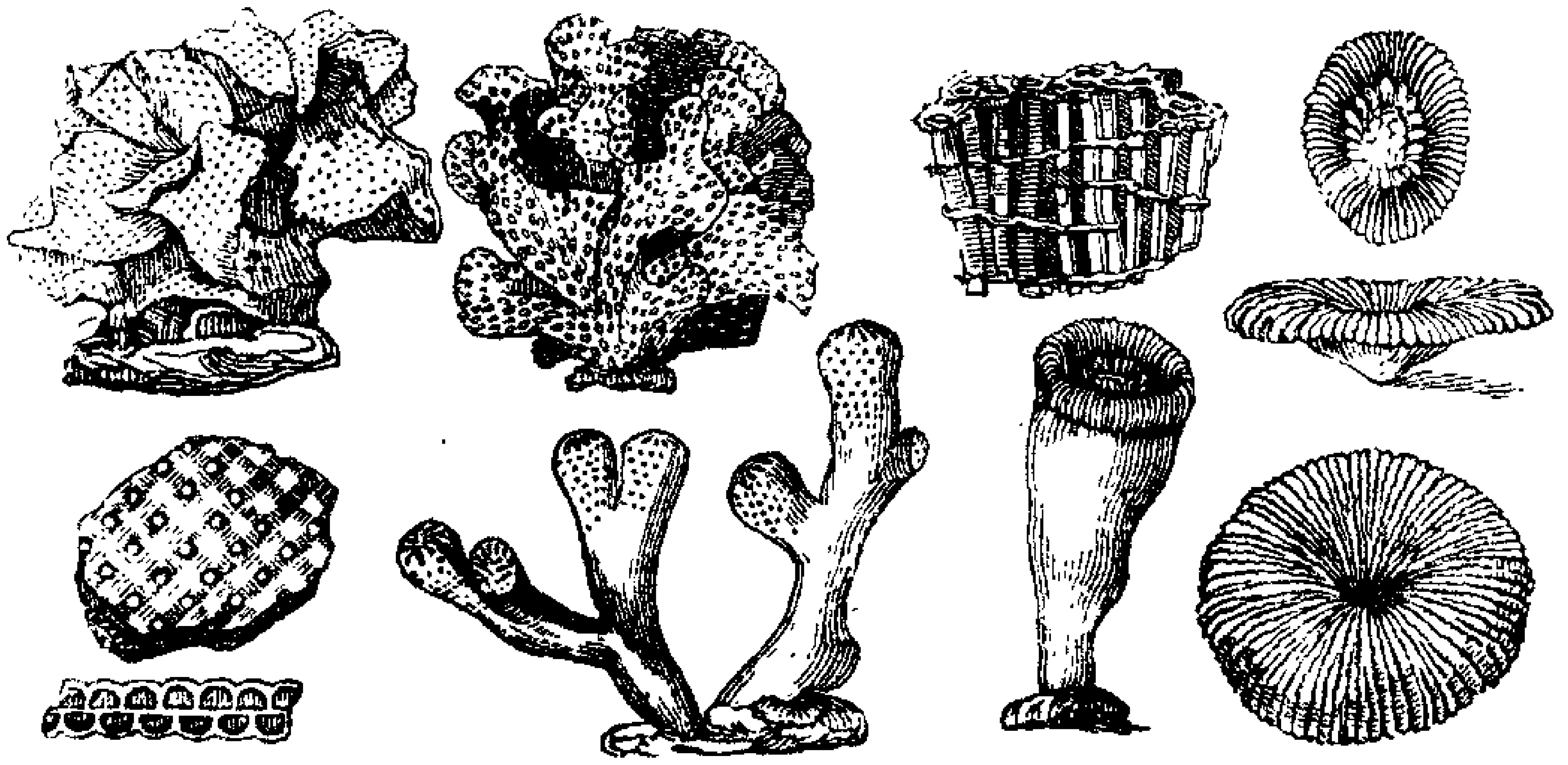
Of the reef-building corals it may well be said that they build for eternity. The bones of the higher animals vanish after a few years, but the stony skeleton of the polyp remains attached to the spot of its formation, and serves as a basement or stage for new generations to build upon. Life and death are here in concurrent or parallel progress; generally the whole interior of a corallum is dead. The large domes of the astræas are in most species covered

with a hemispherical living shell, about half an inch thick; and in some porites of the same size the whole mass is lifeless, except the exterior for a sixth of an inch in depth.



Astræa.

We are astonished when travellers tell us of the vast extent of certain ancient ruins; but how utterly insignificant are the greatest of these when compared with the piles of stone accumulated in the course of ages by these minute, and individually so puny architects! The history of the formation of coral-reefs is no less wonderful than their extent. They have been divided, according to their geological character, into three classes. The first fringes the shores of continents or islands (shore-reefs); the second, rising from a deep ocean, at a greater distance from the land, encircles an island, or stretches like a barrier along the coast (encircling-reefs, barrier-reefs); the third, enclosing a lagoon, forms a ring or annular break-water round an interior lake (atolls, or lagoon-islands).

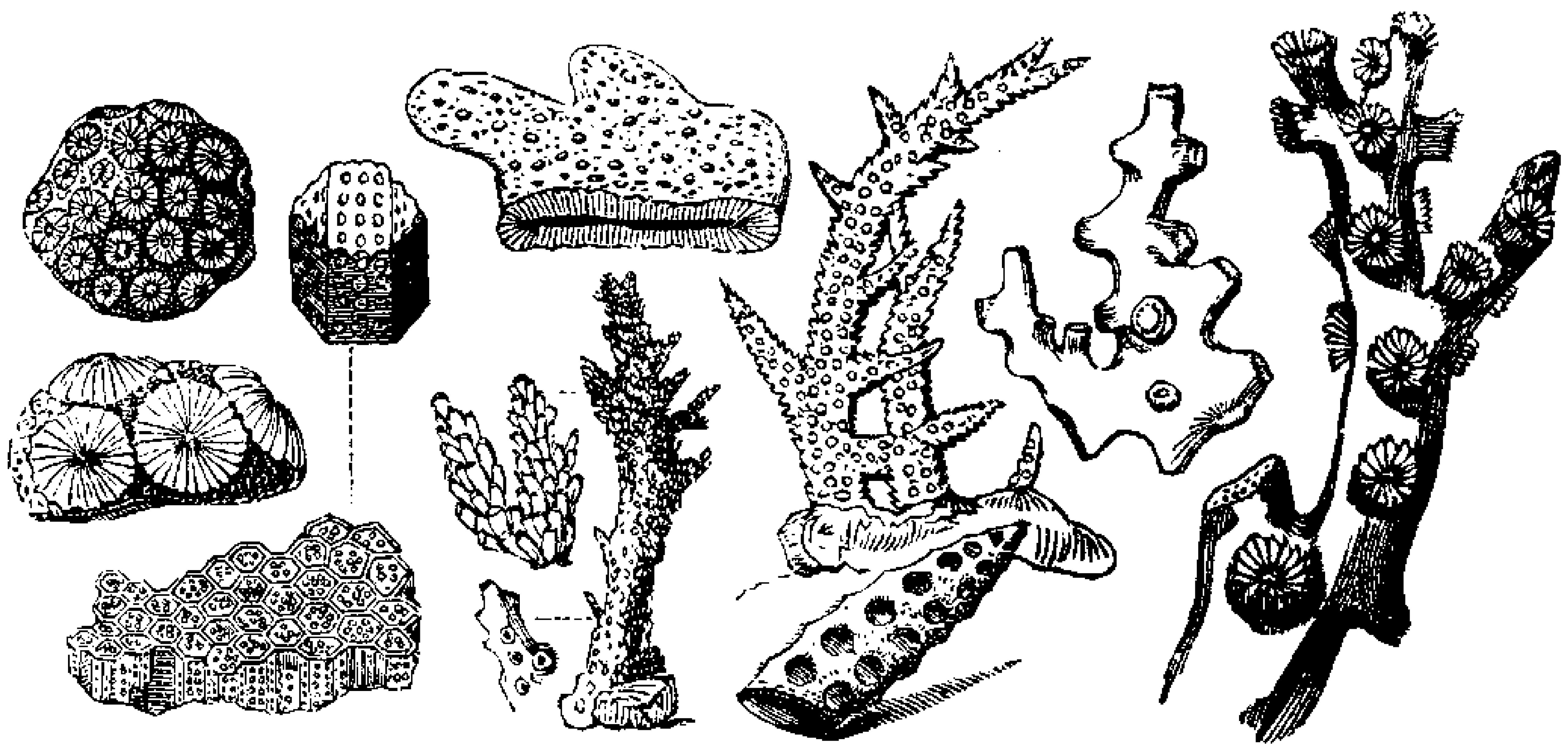


Stone Corals.

Many of the high rocky islands of the Pacific lie, like a picture in its frame, in the middle of a lagoon encircled by a reef. A fringe of low alluvial land in these cases generally surrounds the base of the mountains; a girdle of palm-trees, backed by abrupt heights, and fronted by a lake of smooth water, only separated from the deep blue ocean by the breakers roaring against the encircling reef; such, for instance, is the scenery of

Tahiti, so justly named "the queen of islands." But the encircling reefs are often at a much greater distance from the shore. Thus in New Caledonia they extend no less than 140 miles beyond the island.

As an example of barrier-reefs, I shall cite that which fronts the north-east coast of Australia. It is described by Flinders as having a length of nearly a thousand miles, and as running parallel to the shore at a distance of between twenty and thirty miles from it, and in some parts even of fifty and seventy. The great arm of the sea thus inclosed, has a usual depth of between ten and twenty fathoms. This probably is both the grandest and most extraordinary reef now existing in any part of the world.



Stone Corals.

The atolls, or lagoon-islands, are numerously scattered over the face of the tropical ocean. The Marshall and Caroline islands, the Paumotic group, the Maldives and Lacadives, and many other groups or solitary islets of the Pacific or Indian Ocean, are entirely built up of coral; every single atom, from the smallest particle to large fragments of rock, bearing the stamp of having been subjected to the power of organic arrangement. A narrow rim of coral-reef, generally but a few hundred yards wide, stretches around the enclosed waters. When a lagoon-island is first seen from the deck of a vessel, only a series of dark points is descried just above the horizon. Shortly after, the points enlarge into the plumed tops of cocoa-nut trees,

and a line of green, interrupted at intervals, is traced along the water's surface.

The long swell produced by the gentle but steady action of the trade wind, always blowing in one direction over a wide area, causes breakers which even exceed in violence those of our temperate regions, and which never cease to rage. It is impossible to behold these waves without feeling a conviction that a low island, though built of the hardest rock, would ultimately yield, and be demolished by such irresistible forces. Yet the insignificant coral-islets stand and are victorious; for here another power, antagonistic to the former, takes part in the contest. The organic forces separate the atoms of carbonate of lime one by one from the foaming breakers, and unite them in a symmetrical structure. Let the hurricane tear up its thousand huge fragments, yet what will this tell against the accumulated labours of myriads of architects at work night and day, month after month. Thus do we see the soft and gelatinous body of a polyp, through the agency of vital laws, conquering the great mechanical power of the waves of an ocean, which neither the art of man nor the inanimate works of nature could successfully resist.

The reef-building corals, so hardy in this respect, are extremely sensitive and delicate in others. They absolutely require warmth for their existence, and only inhabit seas the temperature of which never sinks below 60° Fahr. They also require clear and transparent waters. Wherever streams or currents are moving or transporting sediment, there no corals grow, and for the same reason we find no living zoophytes upon sandy or muddy shores.

As within one cast of the lead coral-reefs rise suddenly like walls from the depths of ocean, it was formerly supposed that the polyps raised their structures out of the profound abysses of the sea; but this opinion could no longer be maintained, after Mr. C. Darwin and other naturalists had proved that the lithophytes cannot live at greater depths than twenty or at most thirty fathoms.

Hereupon Quoy and Gaimard broached the theory that corals construct their colonies on the summits of mountain ridges, or the circular crests of submarine craters, and thus accounted both

for the great depths from which the coral-walls suddenly rise, and the annular form of lagoon islands. Yet this theory, ingenious as it was, could not stand the test of a closer examination: for no crater ever had such dimensions as, for instance, one of the Radack Islands, which is fifty-two miles long by twenty broad; and no chain of mountains has its summits so equally high, as must have been the case with the numerous reef-bearing submarine rocks, considering the small depth from which the lithophytes build. Another seemingly inexplicable fact was, that, although corals hardly exist above low-water mark, reefs are found at Tongatabu or Eua, for instance, at elevations of forty and even three hundred feet above the level of the ocean.

Mr. Charles Darwin was the first to give a satisfactory explanation of all the phenomena of coral formations, by ascribing them to the oscillations of the sea bottom, to its partial upheaving or subsidence.

It is now perfectly well known that large portions of the continent of South America, Scandinavia, North Greenland, and many other coasts, are slowly rising, and that other terrestrial or maritime areas are gradually subsiding. Thus on every side of the lagoon of the Keeling Islands, in which the water is as tranquil as in the most sheltered lake, Mr. Darwin saw old cocoa-nut trees undermined and falling. The foundation-posts of a storehouse on the beach, which, the inhabitants said, had stood seven years before just above high water, were now daily washed by the tide.

Supposing on one of these subsiding areas an island-mountain fringed with corals, the lithophytes, keeping pace with the gradual sinking of their basis, soon raise again their solid masses to the level of the water; but not so with the land, each inch of which is irreclaimably gone. Thus the fringing reef will gradually become an encircling one; and, if we suppose the sinking to continue, it must by the submergence of the central land, but upward growth of the ring of coral, be ultimately converted into a lagoon island.

The numerous *atolls* of the Pacific and Indian Ocean give us a far insight into the past, and exhibit these seas overspread with lofty lands where there are now only humble monumental reefs dotted with verdant islets. Had there been no growing

coral, the whole would have passed away without a record; while, from the actual extent of the coral-reefs and islands, we know that the entire amount of the high land lost to the Pacific was at least 50,000 square miles. But as other lands may have subsided too rapidly for the corals to maintain themselves at the surface, it is obvious that the estimate is far below the truth.

As living coral-reefs do not grow above low-water mark, it may well be asked how habitable islands can form upon their crests. The breakers are here the agents of construction. They rend fragments and blocks from the outer border of the reef and throw them upon the surface. Corals and shells are pulverised by their crushing grinding power, and gradually fill up the interstices. In this manner the pile rises higher and higher, till at last even the spring tides can no longer wash over it into the lagoon, on the border of which the fine coral sand accumulates undisturbed. The seeds which the ocean-currents often carry with them from distant continents find here a congenial soil, and begin to deck the white chalk with an emerald carpet. Trees, drifting from the primeval forest, where they have been uprooted by the swelling of the river on whose banks they grew, are also conveyed by the same agency to the new-formed shore, and bring along with them small animals, insects, or lizards, as its first inhabitants. Before the stately palm extends its feathery fronds sea-birds assemble on this new resting-place, and land-birds, driven by storms from their usual haunts, enjoy the shade of the rising shrubbery. At last, after vegetation has completed its work, man appears on the scene, builds his hut on the fruitful soil which falling leaves and decaying herbs have gradually enriched, and calls himself the master of this little world. In this manner all the coral-reefs and islands of the tropical seas have gradually become verdant and habitable; thus has arisen the kingdom of the Maldives, whose sultan, Ibrahim, glories in the title of sultan of the thirteen atolls and twelve thousand isles. May his shadow never be less!

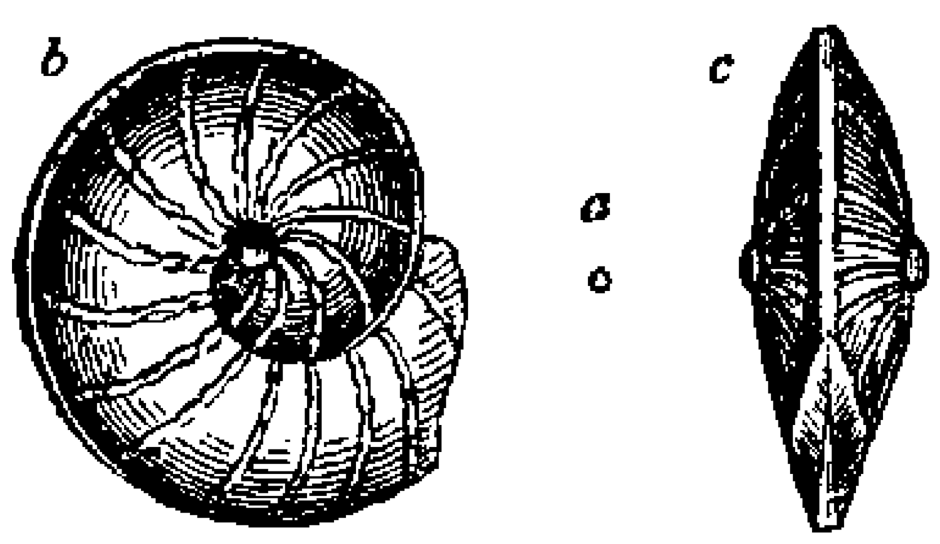
CHAP. XVIII.

PROTOZOA.

The Foraminifera.—The Amœbæ—Their Wonderful Simplicity of Structure.—The Polycystina.—Marine Infusoria.—Sponges—Their Pores—Fibres and Spiculæ—The Common Sponge of Commerce.

THINK not, reader, that the life of the ocean ends with the innumerable hosts of fishes, molluscs, crustacea, medusæ, and polyps we have reviewed, and that the waters of the sea or the sands of the shore have now no further marvels for us to admire. The naked eye indeed may have attained the limits of life, but the microscope will soon reveal a new and wonderful world of animated beings.

Take only, for instance, while wandering on the beach, a handful of drift-sand, and examine it through a magnifying glass. You will then not seldom find, among the coarser grains of inorganic silica, a number of the most elegant shells; some formed like ancient amphoræ, others wound like the nautilus, but all shaped in their minuteness with a perfection which no human artist could hope to equal in the largest size.



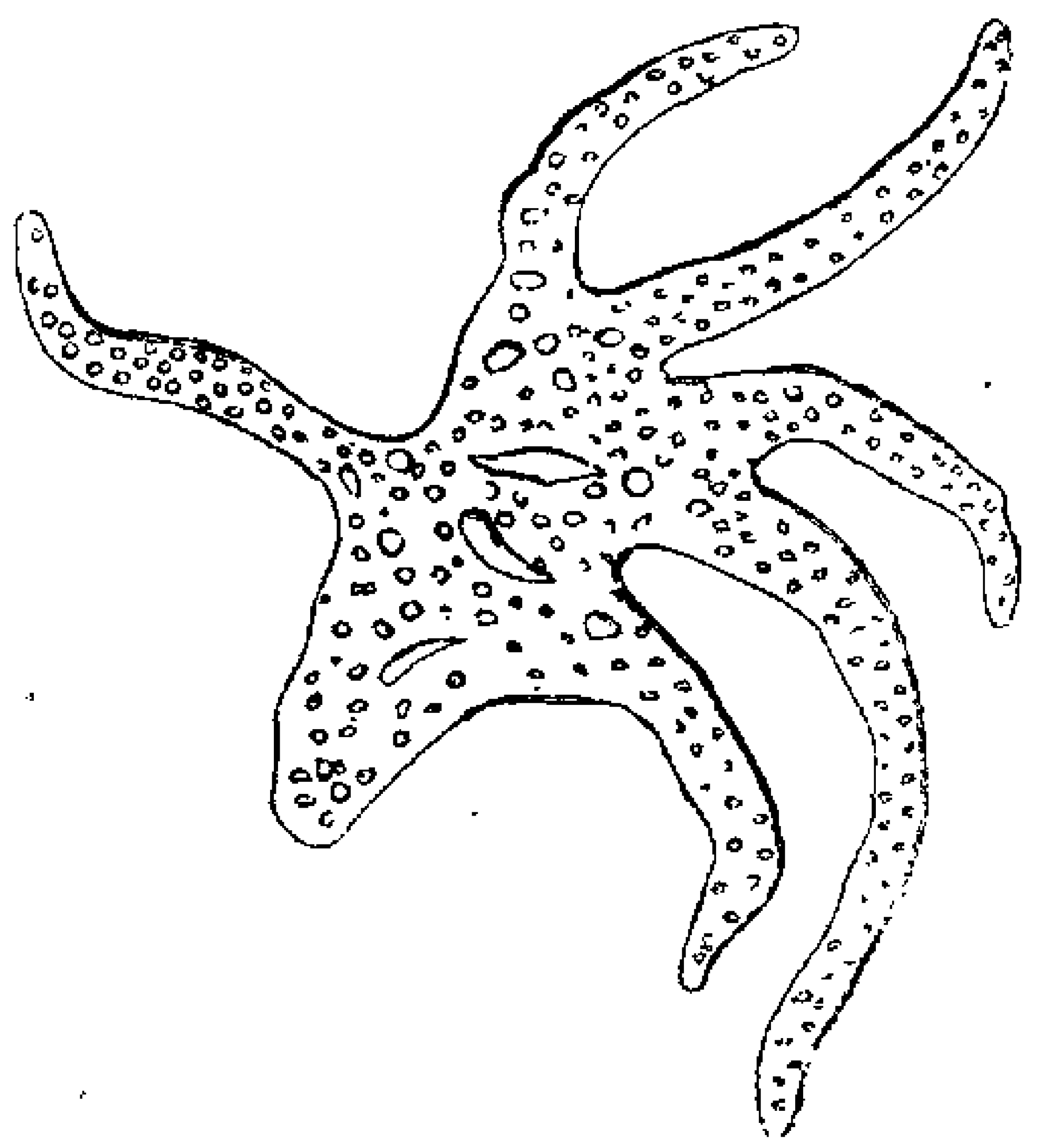
Nummulina discoidalis.
a. Natural size.
b. c. The same, highly magnified.

The knowledge of these charming little marine productions is of modern date, for they were first observed in the sand of the Adriatic by Beccaria in 1731, and for some time believed to belong exclusively to that gulf. At a later period some species were discovered here and there in England and France, but their universality and importance in the economy of the ocean were first pointed out in 1825, by the distinguished French naturalist Alcide d'Orbigny.

The sand of many sea-coasts is so mixed with Foraminifera, as they have been called from the openings with which their shells are pierced, that they often form no less than half its bulk.

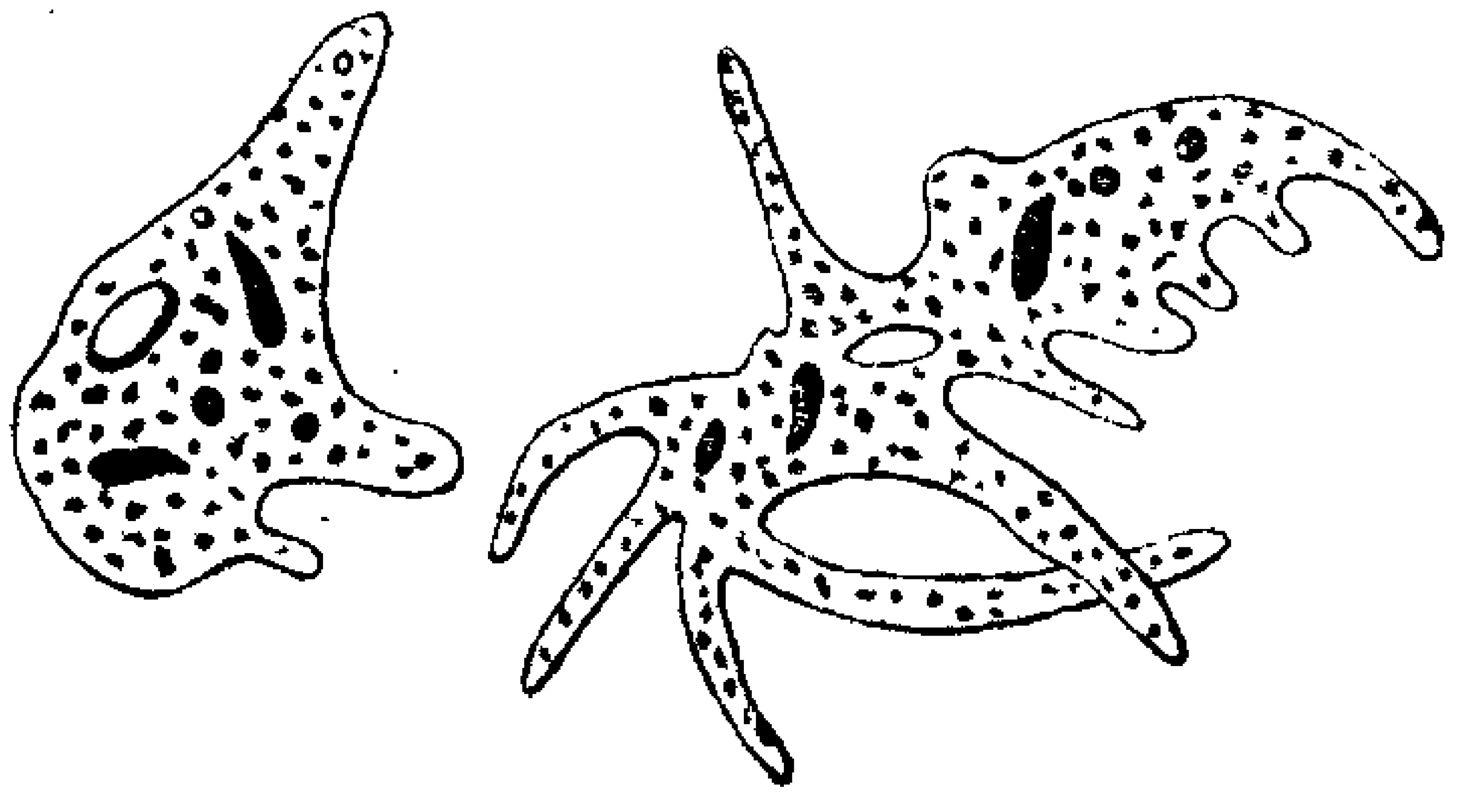
Plancus counted 6000 in an ounce of sand from the Adriatic, and d'Orbigny reckoned no less than 3,849,000 in a pound of sand from the Antilles. Along the whole Atlantic coast of the United States, the plummet constantly brings up masses of foraminiferous shells from a depth of ninety fathoms, so that the vast extent of ocean-bottom, which itself forms but a small part of the domains they occupy, is literally covered with their exuviæ.

Thus their numbers surpass all human conception, nor can any other series of beings be compared to them in this respect; not even the minute crustaceans which colour thousands of square miles on the surface of the sea, and, according to Scoresby, form almost exclusively the food of the huge Greenland whale; nor the infusory animals of the fresh-water, whose shields compose the Bilin slate quarries in Bohemia; for these are limited in their distribution, whereas the Foraminifera occur in all parts of the world.



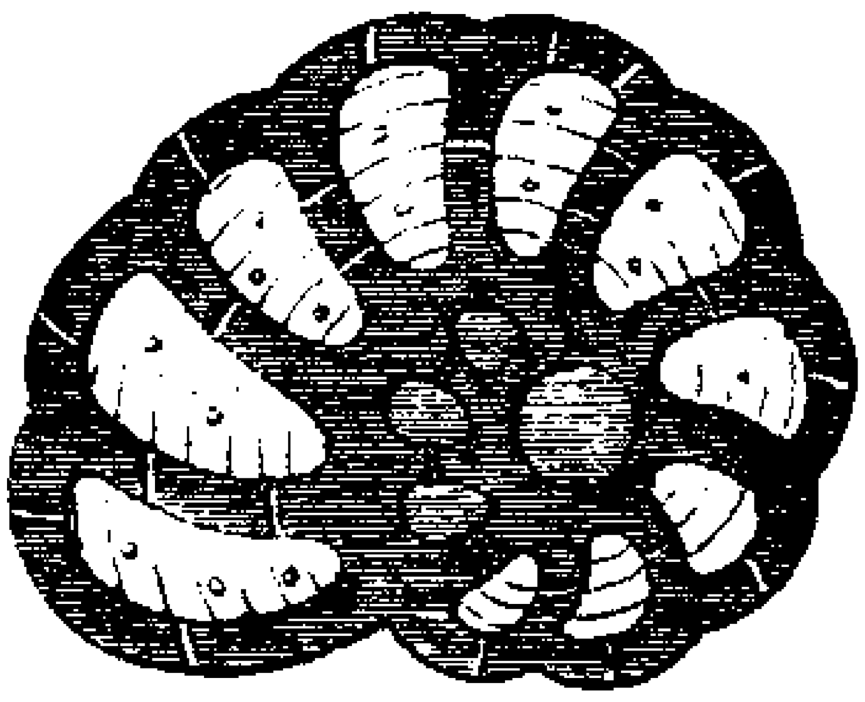
Amœba.

The resemblance of the Foraminifera to the nautili and ammonites at first led naturalists to suppose that they formed part of the same class, which in a long course of centuries had dwindled down in less congenial seas to almost invisible dimensions; but a closer investigation proved them to belong to a much lower order of beings, nearly related to the Amœbæ, which likewise occur all over the ocean. Other animals



Amœba,
showing the extemporaneous feet formed by evanescent projections of the general plastic mass of the animal.

excite our wonder by their complicated structure, but the amœba raises our astonishment by the excessive simplicity of its organisation. The amœba is nothing more than a living globule of mucus, a transparent, colourless, contractile substance, or plastic mass, the individual life of which shows itself in manifold changes of form, bearing the character of voluntary motion. When an amœba approaches another minute animal or plant unable to move out of its reach, it sends out extemporaneous feet, which soon clasp the prey on all sides, and the prisoner lies embedded in the living mucus until all his soluble parts have been absorbed. There is absolutely no trace of particular organs in the amœba; all its constituent particles may be used for any purpose, all equally move and digest, and each can at any time perform the organic functions pertaining to the whole.



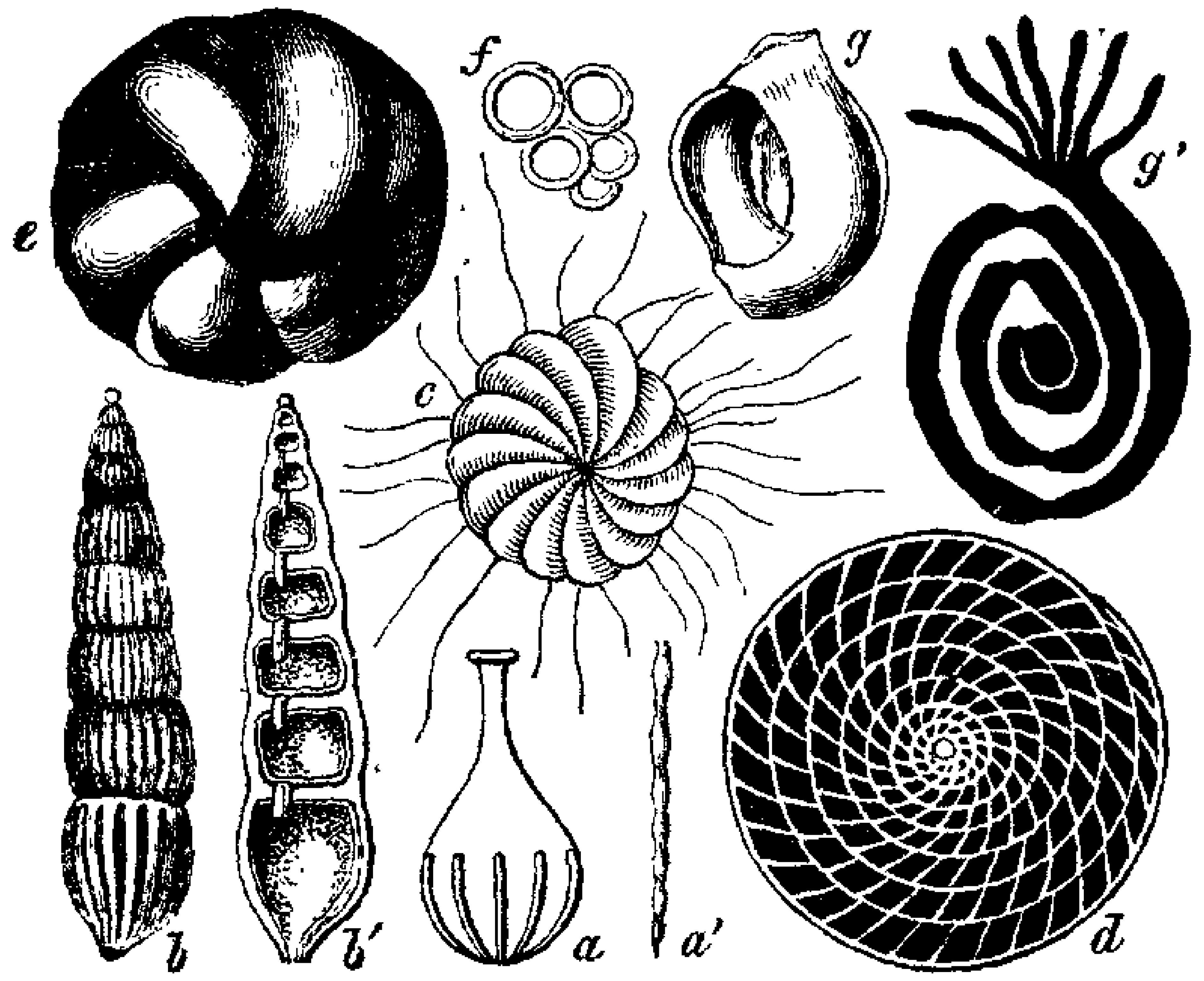
A Compound Foraminiferous Protozoon, magnified.

The shell is perforated with holes, through which the different lobes of the animal communicate, and thread-like portions are protruded externally.

In their internal simplicity the Foraminifera are on a par with the amœbæ, and differ from them only in respect of their outward form. The amœbæ are naked, while the Foraminifera are covered with a shell, out of which, through one or numerous openings, the animal protrudes the processes which it requires for creeping or seizing its prey. These processes or filaments of mucus frequently ramify, closing as they spread, and sometimes covering an area of several lines in diameter, in the centre of which the animal inclosed in its shell waits for its prey, like a spider in its net.

The extended filaments appear to have something venomous about them; for Dr. Schultze, to whom we owe an interesting monograph on the Foraminifera, frequently saw small and sprightly parameciæ, colpodes, and other infusoria drop down paralysed as soon as they touched the net.

The amazing variety of form of the Foraminifera is no less remarkable than the elegance of their delicately chiselled shells, and may well be called immense, as no less than 2,400 living and fossil species have already been distinguished by naturalists, and a far greater number is probably still nameless and unknown. Though generally so minute that the diameter of



Various forms of Foraminifera.

a. Lagena striata. a'. Nodosaria rugosa. b. Marginulina raphanus.
b'. Longitudinal section of shell of ditto. *c. Polystomella crispa,* with its pseudopodia protruded.
d. Nummulites lenticularis, shown in horizontal section. *e. Cassidulina lævigata.*
f. Textularia globulosa. g. Miliolina seminulum. g'. Animal of Miliolina removed from its shell.

the pores through which they protrude their filaments usually only ranges from $\frac{1}{3000}$ to $\frac{1}{10000}$ of an inch yet the diminutive world of the Foraminifera has also its giants, particularly among the fossil species, such as the Nummulites, which occur in such prodigious numbers in the limestone of the Egyptian pyramids, and whose flattened lenticular coin-like forms (*d*) attain the comparatively gigantic diameter of several inches. Thus the material with which the proud Pharaohs of the Nile constructed their colossal tombs was originally piled up at the bottom of the sea by countless generations of shell-cased Protozoa.

The Foraminifera are among the oldest inhabitants of our globe,* and as the present ocean contains them in countless

* The *Eozoon canadense*, the oldest of known organic remains, found in the Upper Laurentian series, which preceded the Cambrian formation, is a Foraminifer. Millions of years must have passed since it first felt and moved.

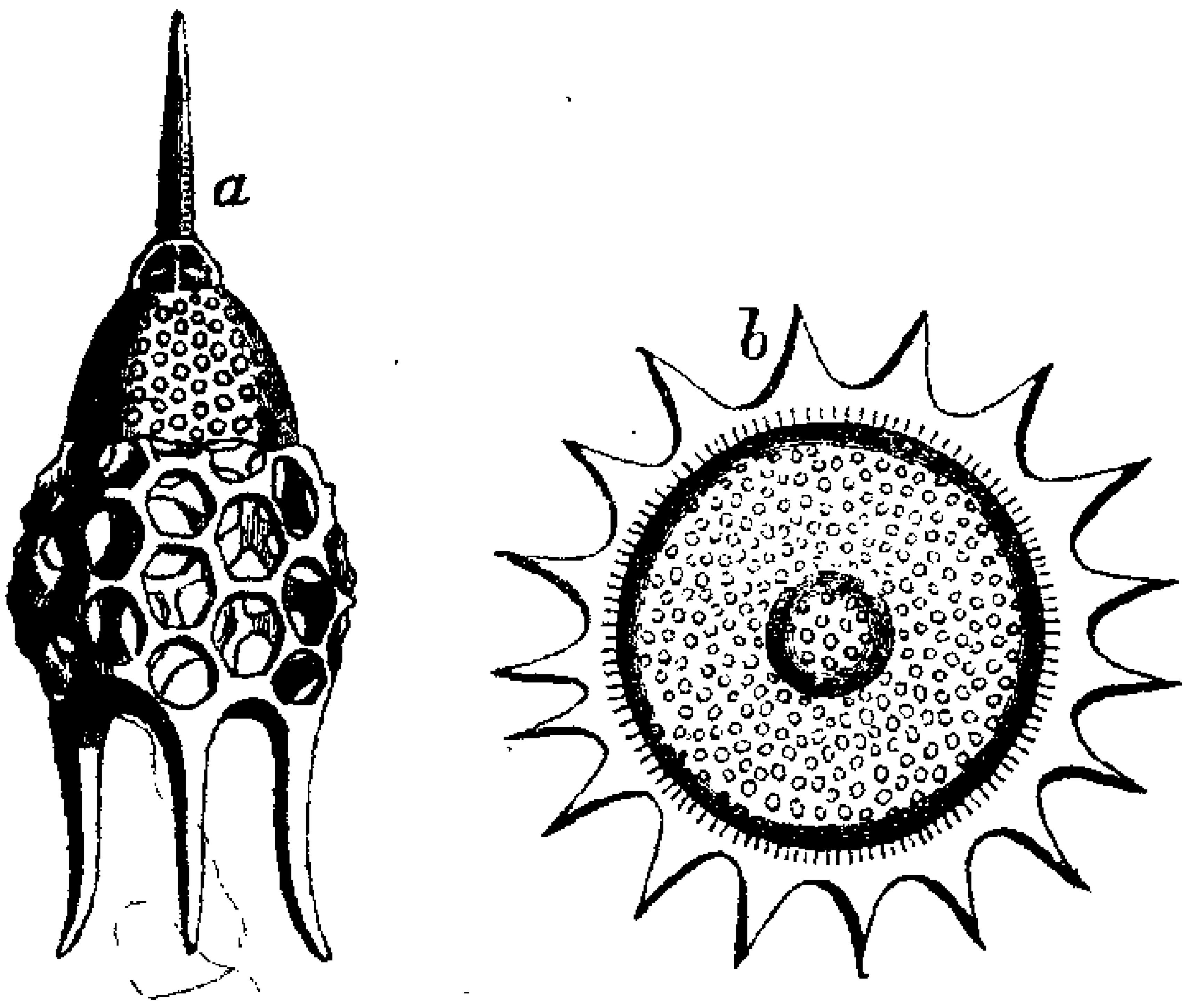
multitudes, thus have they swarmed in the waters of the primeval seas from the first dawn of creation, and piled up the monuments of their existence in vast strata of limestone. A great part of the rocky belt from Rügen to the Danish isles, the white chalk cliffs which, beginning in England, extend through France as far as Southern Spain, are chiefly composed of the shells of Foraminifera, and the zone of Nummulite limestone, which served to build the huge quadrilateral monument of Cheops, forms a band, often 1,800 miles in breadth, and frequently of enormous thickness, from the Atlantic shores of Europe and Africa through Western Asia up to North India and China; enough to satisfy the most extravagant architectural folly of millions of despots. So important is the part which these beings, individually so minute, have performed and still perform in the geological annals of the globe.

Many of these "minims of nature" consist of only one chamber, and hence are called unilocular or monothalamous; but a vast proportion consist of several chambers, and hence are called multilocular or polythalamous. The latter, however numerous their chambers or seemingly complex their structure, always originate as a single shell. The primitive jelly-sphere, or first sarcode segment, secretes around itself its appropriate calcareous envelope. Having grown too large for its habitation, it protrudes a portion of itself without, and thus forms a second segment. If by a process of spontaneous fission this segment becomes quite detached from its parent, and repeats the life and method of reproduction of the latter, a series of monothalamous shells will be formed. But if by means of a sarcode band the primitive segment maintains its connection with its immediate offspring, and this, repeating the reproductive process, does the same, a compound shell will, of course, be the result.

Among the microscopic denizens of the ocean, the Polycystina rival the Foraminifera both by their number and their wonderful elegance of form and structure. Their body consists of the same viscid homogeneous plastic mass, termed "sarcode" by the naturalists; like them they are capable of protruding it through the foramina with which their shell is pierced, and consequently they are ranked with them among the Rhizopods,

or root-footed animalcules, that form the lowest order of the Protozoa, the lowest class of the animal world.

It is a peculiar feature of these beautiful little shells (whose delicate sculpture frequently reminds the observer of the finest specimens of the hollow ivory balls carved by the Chinese) that they are usually surmounted by a number of spine-like projections, very frequently having a radiate disposition. Some have an oblong shape (Podocyrtis), others a discoid form (Ha-



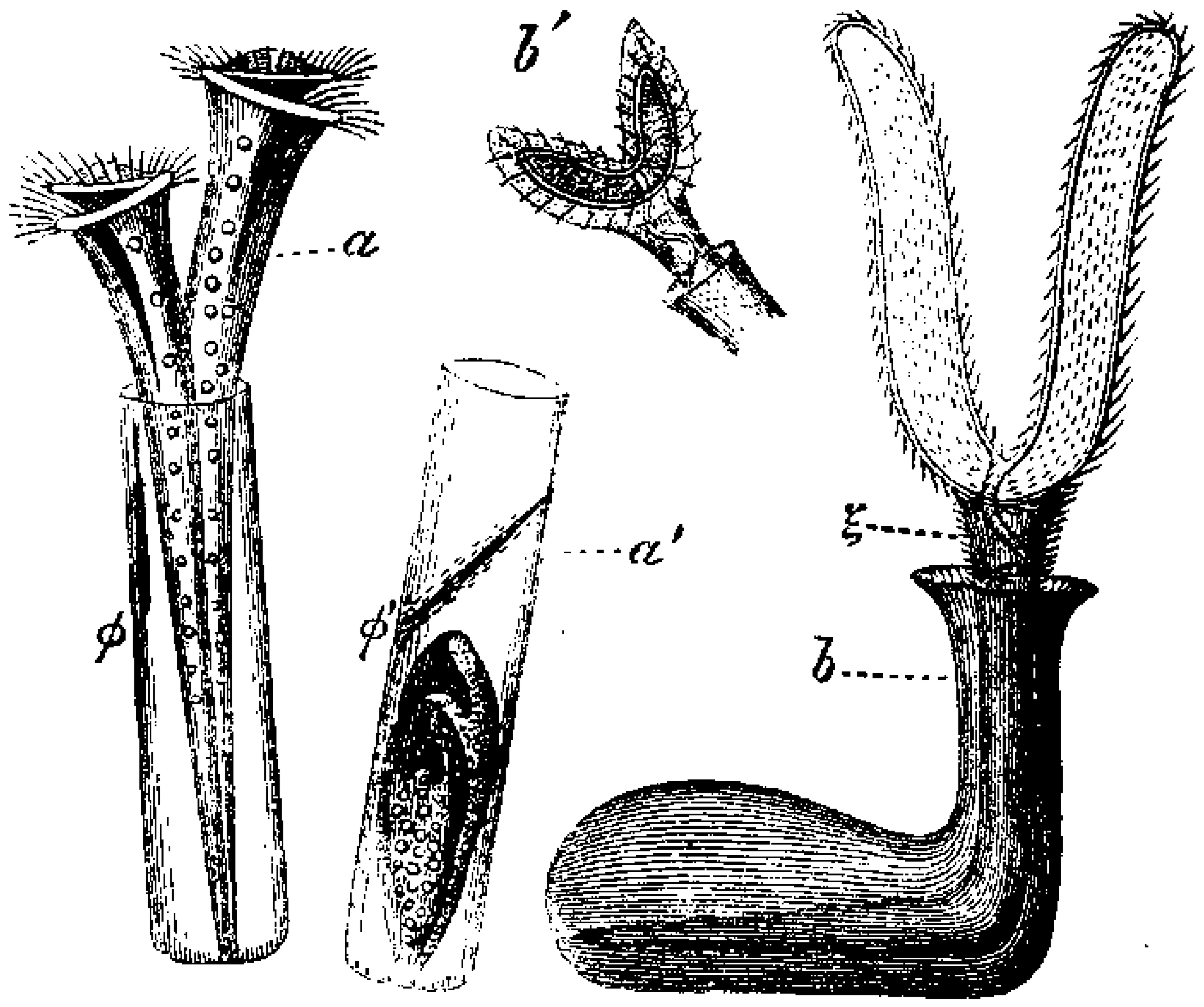
Polycystina.

a. Podocyrtis Schomburgkii. *b. Haliomma Humboldtii.*

liomma), from the circumference of which the silicious spines project at regular intervals, so as to give them a star-like aspect. They are generally of a smaller size than even the Foraminifera, appear to be almost as widely diffused, and have also largely contributed to the structure of the earth-rind. They were first discovered by Professor Ehrenberg at Cuxhaven, on the North Sea; they were afterwards found by him in collections made in the antarctic seas, and have been brought up by the sounding lead from the bottom of the Atlantic at depths of from 1,000 to 2,000 fathoms.

The term Infusoria, which formerly comprised a most heterogeneous assemblage of minute plants and animals, is now confined to the highest order of the Protozoa, distinguished from the Rhizopods by the possession of a mouth and of ciliary filaments, whose vibrations serve them both for pro-

gression through the water and for drawing alimentary particles into the interior of their body. Though most of the Infusoria live in ponds, morasses, pools, wells, or cisterns, yet many are marine, as, for instance, the *Carchesium polypinum*, which is frequently found attached to corallines, and the *Vaginicola valvata*, which from its sheath and valve strongly reminds one of a tubicolar annelide.

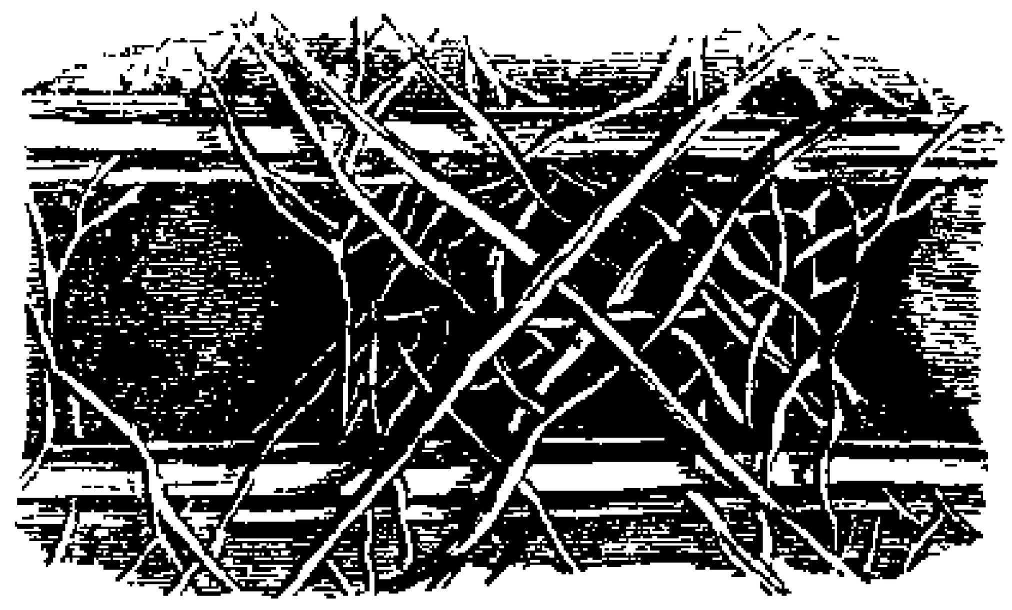


Marine Infusoria.

a. Vaginicola valvata, showing animal extended, and valve (φ) raised.
a'. The same, showing animal contracted within its sheath, and valve (φ') shut down.
b. Lagotia viridis, showing rotatory organ (ξ). *b'*. Young animal of preceding.

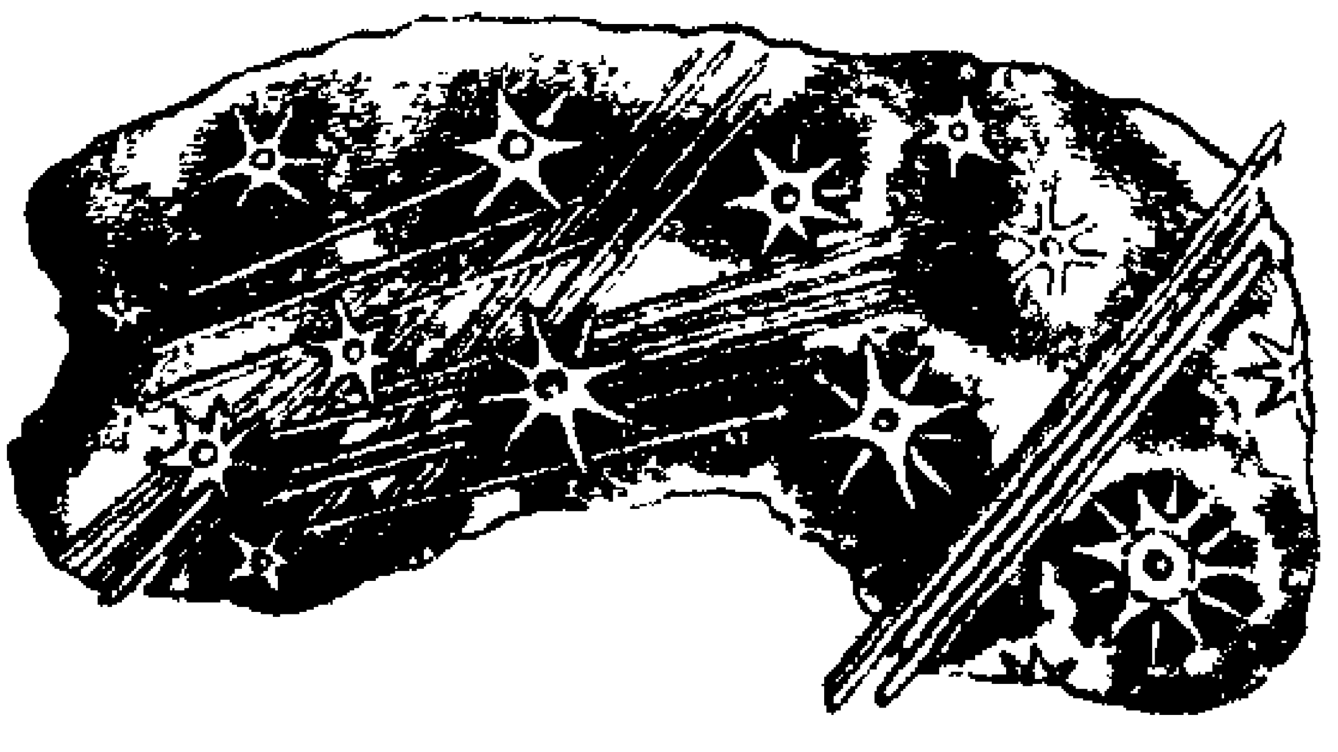
The wide diffusion both in time and space of the marine Protozoa, and chiefly of the Foraminifera and Polycystina, is a sufficient proof of their vast importance in the household of the seas. Along with the Diatoms and other microscopical forms of vegetation on which their own existence depends, they evidently constitute the basis on which the superstructure of all the higher orders of the animal life of the ocean reposes. Hosts of minute crustaceans, annelides, acalephæ, and molluscs, feed upon their inexhaustible legions, and serve in their turn to sustain creatures of a larger and still larger size until finally Man is enabled to feast on the abundance of the seas.

The Porifera, or Sponges, were formerly supposed to belong to the vegetable kingdom, but their animal nature is now fully ascertained, for modern researches have proved that the soft glairy substance with which their skeleton is invested during life consists of "sarcode," similar to that which forms the soft parts of the Foraminifera and Polycystina. It is by this animated or organic gelatine, which can generally be pressed out with the finger, and in some species is copious even to nauseousness, that the solid parts of the sponge are deposited, and from it the whole growth of the mass proceeds. The framework or skeleton of the Porifera is usually composed of horny fibres of unequal thickness, which ramify and interlace in every possible direction, anastomosing with each other so as to form innumerable continuous cells and intricate canals, the walls of which in the recent sponge are crusted over with the gelatinous living cortex.



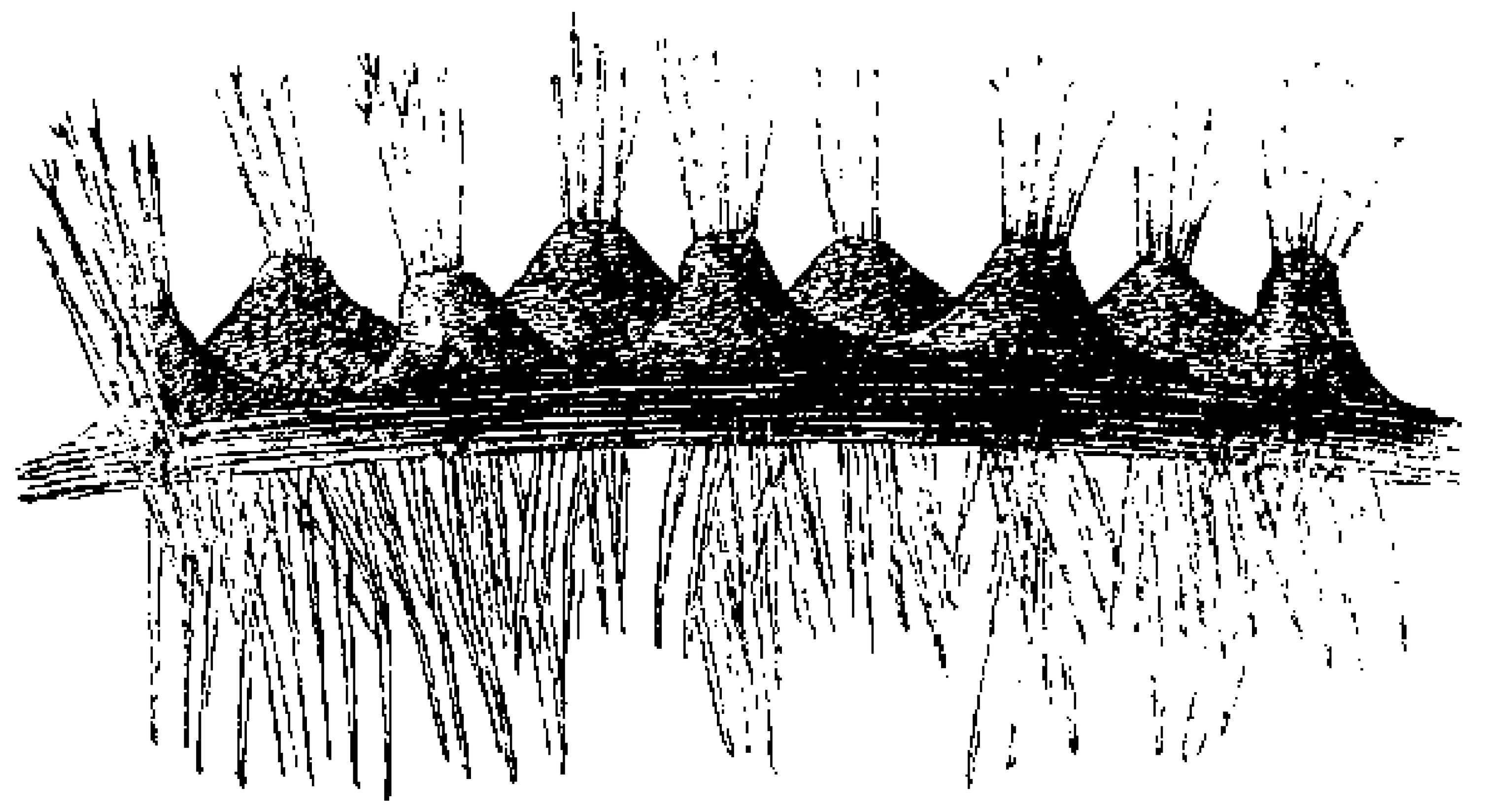
Single interspace or open cell, and surrounding finer meshwork of the skeleton of a sponge.

Generally this fibrous mass is interwoven with numerous mineral spicules of a wonderful elegance and variety of forms, for their shapes are not only strictly determinate for each species of sponge but each part of the sponge, it is believed, has spiculæ of a character peculiar to itself. Sometimes they are pointed at both ends, sometimes at one only, or one or both ends may be furnished with a head like that of a pin, or may carry three or more diverging points, which sometimes curve back so as to form hooks. Sometimes they are triradiate, sometimes stellar; in some cases smooth, in others beset with smaller spinous projections like the lance of the saw-fish. In many species they are embedded in the horny framework; in others, as, for instance, in Tethea Cranium, or in Halichondria, they project from its surface like a tiny forest of spears. They are generally composed of silex or flint, but in the



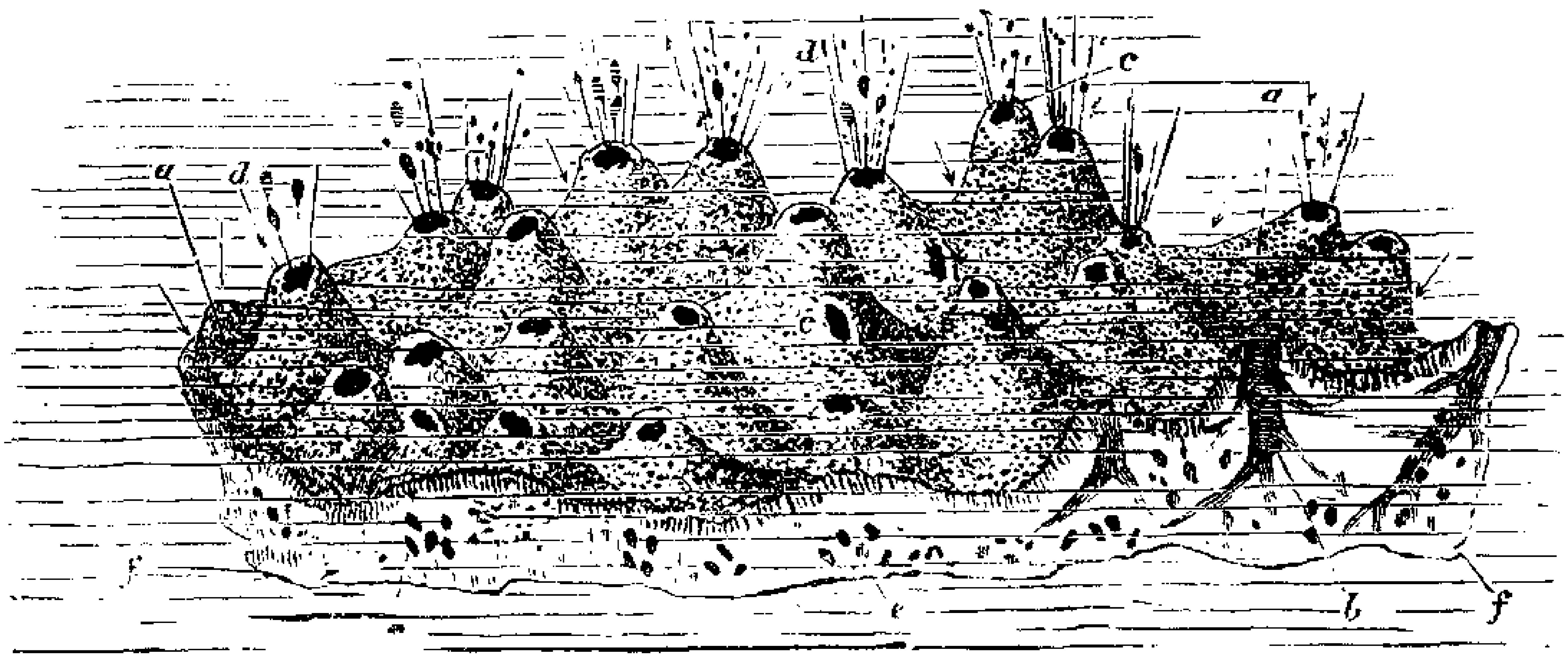
Needle-like and starred spicula of a Tethea. (Highly magnified.)

genus Grantia they consist of carbonate of lime. Though the skeleton of most sponges is formed both of horny fibres and of mineral spicules yet the proportions of these two component parts vary considerably in different species. In the common sponge, for instance, the fibrous skeleton is almost entirely destitute of spicules, a circumstance to which it owes the flexibility and softness that render it so useful to man, while they predominate in the Halichondriæ, and sometimes even, as in the Grantiæ, completely supersede the horny fabric.



Minute portion of the surface of Tethea Cranium, magnified, spicula projecting beyond the surface.

On examining a sponge, the holes with which the substance is everywhere pierced may be seen to be of two kinds; one of larger size than the rest, few in number, and opening into wide channels and tunnels which pierce the sponge through its centre; the other minute, extremely numerous, covering the



Halina papillaris.
Currents passing inwards through the pores (*a a*), traversing the internal canals (*b*), and escaping by the larger vents (*c*, *d*).

wide surface, and communicating with the innumerable branching passages which make up the body of the skeleton. Through the smaller openings or pores the circumambient water freely enters the body of the sponge, passes through the smaller canals, and, ultimately reaching the larger set of vessels, is evolved through the larger apertures or oscula. Thus by a still mysterious agency (for the presence of cilia has as yet been

detected but in one genus of full-grown marine sponges) a constant circulation is kept up, providing the sponge with nourishing particles and oxygen, and enabling its system of channels to perform the functions both of an alimentary tube and a respiratory apparatus.

Dr. Grant describes in glowing terms his first discovery of this highly interesting phenomenon: "Having put a small branch of sponge with some sea-water into a watch-glass, in order to examine it with the microscope, and bringing one of the apertures on the side of the sponge fully into view, I beheld for the first time the spectacle of this living fountain, vomiting forth from a circular cavity an impetuous torrent of liquid matter, and hurling along in rapid succession opaque masses, which it strewed everywhere around. The beauty and novelty of such a scene in the animal kingdom long arrested my attention, but after twenty-five minutes of constant observation, I was obliged to withdraw my eye from fatigue, without having seen the torrent for one instant change its direction or diminish in the slightest degree the rapidity of its course. I continued to watch the same orifice at short intervals for five hours, sometimes observing it for a quarter of an hour at a time, but still the stream rolled on with a constant and equal velocity."

Subsequent observations have proved that the living sponge has the power of opening and closing at pleasure its oscula, which are capable of acting independently of each other, thus fully establishing the animal nature of these simple organisations, in whom latterly even traces of sensibility have been detected, such as one would hardly expect to meet with in a sponge. For these creatures, as we are entitled to call them, are able to protrude from their oscula the gelatinous membrane which clothes their channels, and on touching these protruded parts with a needle, they were seen by Mr. Gosse to shrink immediately—a proof that the sponge, however low it may rank in the animal world, is yet far from being so totally inert or lifeless as was formerly imagined.

The propagation of the sponges is provided for in a no less wonderful manner than their respiration and nourishment. Minute globular particles of sarcode sprout forth as little protuberances from the interior of the canals. As they increase in

size, they are gradually clothed with vibratile cilia, and, finally detaching themselves, are cast out through the oscula into the world of waters. Here their wanderings continue for a short time, until, if they be not devoured on the way, they reach some rock or submarine body on which, tired of their brief erratic existence, they fix themselves for ever, and, bidding adieu to all further rambles, lead henceforth the quiet sedentary life of their parents. In this manner the sponges, which otherwise would have been confined to narrow limits, spread like a living carpet over the bottom of the seas, and in spite of their being utterly defenceless, maintain their existence from age to age. At the same time they serve to feed a vast number of other marine animals, for the waters frequently swarm with their eggs, and these afford many a welcome repast to myriads of sessile molluscs, annelides, polyps, and other creatures small or abstemious enough to be satisfied with feasting on atoms.

Sponges inhabit every sea and shore, and differ very much in habit of growth. For whilst some can only be obtained by dredging at considerable depths, others live near the surface, and others, again, attach themselves to the surfaces of rocks and shells between the tide marks. Like the corals, they revel in every variety of shape and tint, imitate like them every form of vegetation, and adorn like them the submarine grounds with their fantastic shrubberies. The fine collection of West Indian sponges exhibited in the Crystal Palace, but to which fancy must add the additional ornament of colour, may serve to give some idea of their prodigal versatility of growth. More than sixty different species have been discovered in the British waters alone, and as they go on increasing in numbers, size, and beauty, until they attain their highest development along the shores of the tropical ocean, they no doubt hold a conspicuous rank among the living wonders of the sea. The branched sponges, with a compact feltred tissue, are more common than others in the colder maritime domains, where the species of a loose texture, which grow in large massive forms, either do not exist or are very rare. Many sponges are of considerable size, such as the vase-like tropical species known under the name of Neptune's cup; others are almost microscopical; and while by far the greater number grow superficially from a solid base, some penetrate like destructive parasites into the texture of other animals. Thus the

Halichondria celata establishes itself in the small holes which some of the smaller annelides drill in the shell of the oyster, eat further and further into the unfortunate mollusc's vitals, causing the softer parts of the shell to rot away, and spread through its whole substance, like the dry-rot fungus through a solid beam of timber, until, sinking under the weight of his misery, the poor victim perishes, and his loosened shell is ca.t to the mercy of the waves. On the other hand, some marine Acorn-shells nestle habitually in a sponge, the normal construction of the base of the shell being altered to suit the peculiarities of its habitation, so that in this instance, as in many others, there is a foreseen relation between two very dissimilar animals. Amongst the reticulated fibres of its spongy dwelling, the Acorn-shell finds a secure refuge in its infant state, and is soon enclosed by the growing fabric of the sponge-animal, except a small opening, which is kept clear by the vortex occasioned by the constant motion of its feelers or tentacula.

But very few of the manifold species of sponges are of any use to man. The common sponge of commerce (*Spongia communis*), so serviceable in our households, is most abundant in the Lycian seas, where it is found attached to rocks at various depths between three fathoms and thirty. When alive, it is of a dull bluish black above, and dirty white beneath. There are several qualities, possibly indicating as many distinct species.

"The most valued kinds," says Edward Forbes, "are sought for about the Gulf of Macri, along the Carian coast, and round the opposite islands. The species which live immediately along the shore near the water's edge, though often large, are worthless. These are of many colours; some of the brightest scarlet or clear yellow form a crust over the faces of submarine rocks; others are large and tubular, resembling holothuriæ in form and of a gamboge colour, which soon turns to dirty brown when taken out of the water; others are again lobed or palmate, studded with prickly points, and perforated at intervals with oscula. These grow to a considerable size, but, like the former, are useless, since their substance is full of needles of flint."

Large quantities of excellent sponge (*Spongia usitatissima*) are likewise imported from the West Indies.

CHAP. XIX.

MARINE PLANTS.

The Algæ.—Zostera marina.—The Ulvæ and Enteromorphæ.—The Fuci.—The Laminariæ.—Macrocystis pyrifera.—Description of the Submarine Thickets at Tierra del Fuego.—Nereocystis lutkeana.—The Sargasso Sea.—The Gathering of edible Birds'-nests in the marine Caves of Java.—Agar-Agar.—The Florideæ.—The Diatomaceæ—Their importance in the economy of the Seas.

The dry land develops the most exuberant vegetation on the lowest grounds, the plains and deep valleys, and the size and multiplicity of plants gradually diminish as we ascend the higher mountain regions, until at last merely naked or snow-covered rocks raise their barren pinnacles to the skies: but the contrary takes place in the realms of ocean; for here the greater depths are completely denuded of vegetation, and it is only within 600 or 800 feet from the surface that the calcareous nullipores begin to cover the sea-bottom, as mosses and lichens clothe the lofty mountain-tops. Gradually corallines and a few algæ associate with them, until finally about 80 or 100 feet from the surface begins the rich vegetable zone which encircles the margin of the sea. The plants of which it is composed do not indeed attain the same high degree of development as those of the dry land, being deprived of the beauties of flower and fruit: but as the earth at different heights and latitudes constantly changes her verdant robe, and raises our highest admiration by the endless diversity of her ornaments, thus also the forms of the sea-plants change, whether we descend from the brink of ocean to a greater depth, or wander along the coast from one sea to another; and their delicate fronds are as remarkable for beauty of colour and elegance of outline, as the leaves of terrestrial vegetation.

The difference of the mediums in which land- and sea-plants exist naturally requires a different mode of nourishment, the

former principally using their roots to extract from a varying soil the substances necessary for their perfect growth, while the latter absorb nourishment through their entire surface from the surrounding waters, and use their roots chiefly as holdfasts.

The constituent parts of the soil are of the greatest importance to land-plants, to whose organisation they are made to contribute; while to the sea-plant it is generally indifferent whether the ground to which it is attached be granite, chalk, slate, or sandstone, provided only its roots find a safe anchorage against the unruly waters.

Flat rocky coasts, not too much exposed to the swell of the waves, and interspersed with deep pools in which the water is constantly retained, are thus the favourite abode of most algæ, while a loose sandy sea-bottom is generally as poor in vegetation as the Arabian desert.

But even on sandy shores extensive submarine meadows are frequently formed by the Grass Wrack (*Zostera marina*), whose creeping stems, rooting at the joints and extending to a considerable depth in the sand, are admirably adapted for securing a firm position on the loose ground. Its long riband-like leaves, of a brilliant and glossy green, wave freely in the water, and afford shelter and nourishment to numerous marine animals and plants. In the tropical seas it forms the submarine meadows on which the turtles graze, and in the North of Europe it is used for the manufacture of cheap bedding. It also furnishes an excellent material for packing brittle ware.

Sea-weeds are usually classed in three great groups, green, olive-coloured, and red; and these again are subdivided into numerous families, genera, and species.

On the British coasts alone about 400 different species are found, and hence we may form some idea of the riches of the submarine flora. Thousands of algæ are known and classified, but no doubt as many more at least still wait for their botanical names, and have never yet been seen by human eye.

The *Green* sea-weeds, or Chlorospermeæ, generally occur near high-water mark, and love to lead an amphibious life, half in the air and half in salt-water. The delicate Enteromorphæ, similar to threads of fine silk, and the broad brilliant Ulvæ, which frequently cover the smooth boulders with a glossy vesture of lively green, belong to this class. Many of them are remarkable for

their wide geographical distribution. Thus the *Ulva latissima* and the *Enteromorpha compressa* of our shores thrive also in the cold waters of the Arctic Sea, fringe the shores of the tropical ocean, and project into the southern hemisphere as far as the desolate head-lands of Tierra del Fuego. But few animals or plants possess so pliable a nature, and such adaptability to the most various climates.

The *Olive-coloured* group of sea-weeds, or Melanospermeæ, plays a much more considerable part in the economy of the ocean. The common fuci, which on the ebbing of the tide impart to the shore cliffs their peculiar dingy colour, belong to this class; as well as the mighty Laminariæ, which about the level of ordinary low water, and one or two fathoms below that limit, fringe the rocky shore with a broad belt of luxuriant vegetation.

The first olive-coloured sea-weed we meet with on the receding of the flood is the small and slender *Fucus canaliculatus*, easily known by its narrow grooved stems and branches, and the absence of air-vessels. Then follows *Fucus nodosus*, a large species, with tough thong-like stems, expanding at intervals into knob-like air-vessels, and covered in winter and spring with bright yellow berries. Along with it we find the gregarious *Fucus vesiculosus*, with its forked leaf traversed by a midrib, and covered with numerous air-vessels situated in pairs at each side of the rib. Finally, about the level of half-tide, a fourth species of fucus appears, *Fucus serratus*, distinguished from all the rest by its toothed margin and the absence of air-vessels.

These four species generally occupy the littoral zone of our sea-girt isle, being found in greatest abundance on flat rocky shores, particularly on the western coasts of Scotland and Ireland, where they used formerly to be burnt in large quantities for the manufacture of kelp or carbonate of soda, which is now obtained by a less expensive process. In Orcadia alone more than 20,000 persons were employed during the whole summer in the collection and incineration of sea-weeds, a valuable resource for the poverty-stricken islanders, of which they have been deprived by the progress of chemical science.

The fuci are, however, still largely used, either burnt or in a fermented state, as a valuable manure for green crops. Thus

A RUSSIAN OFFICIAL, ATTENDED BY A SOLDIER, COLLECTING ALGÆ ON THE SHORES OF THE NORTH PACIFIC.

THE annexed plate is taken from the frontispiece of the magnificent folio volume by Messrs. Ruprecht and Postels, on the Algæ of the North Pacific. This work, in which even the largest of the marine plants of that region are represented of their natural size, was published at the expense of the Russian Government, and copies were presented to some of the principal libraries of Europe.

In the middle distance, a Russian official belonging to one of the settlements is seen gathering algæ, attended by a soldier.

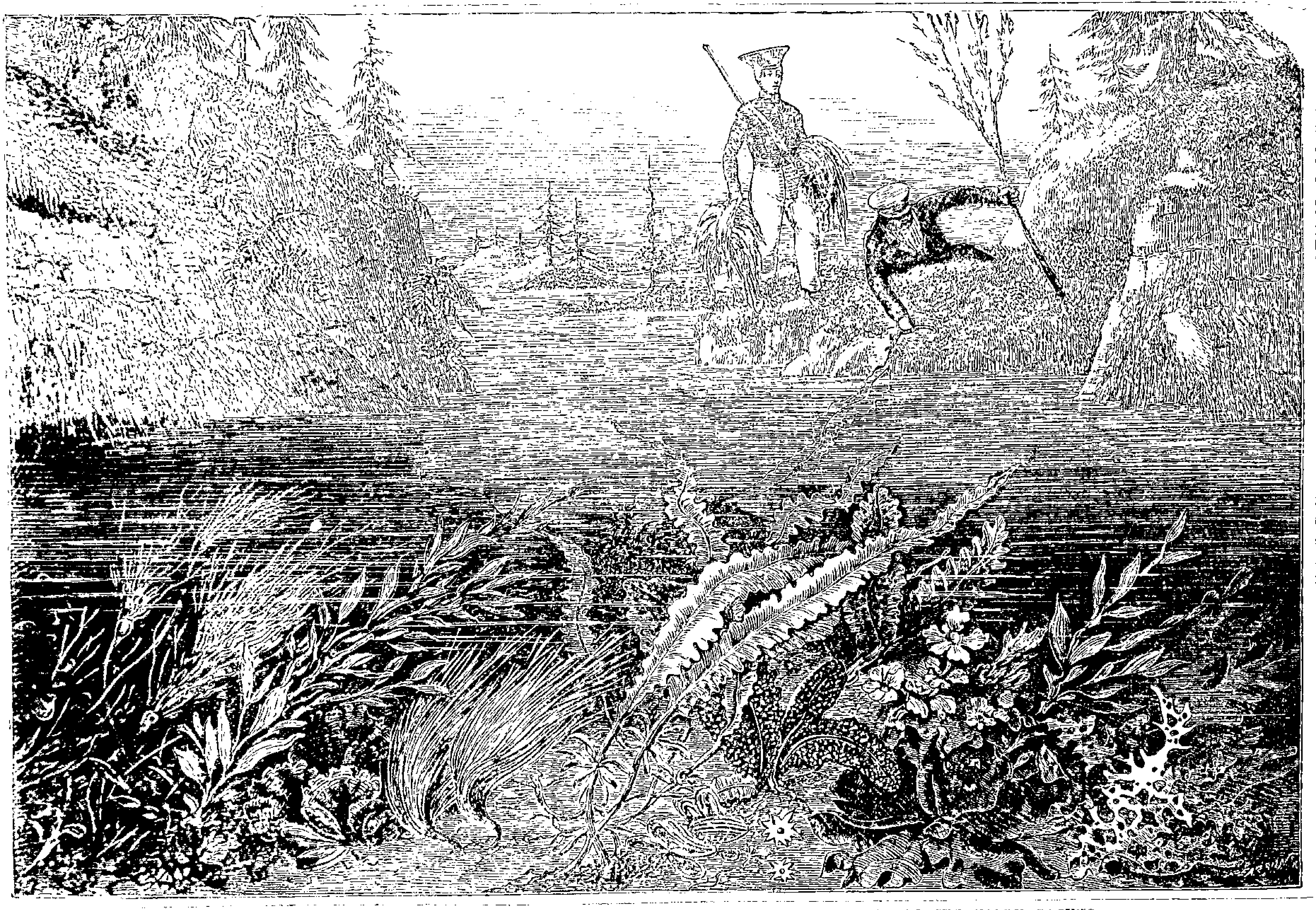
In the front of the picture the water is supposed to be so clear as to show distinctly the growth of sea-weeds of various kinds, which clothe the submarine rocks in that region. Some species of these have been added to the number shown in the original composition.

In the centre, with the light fully upon them, are streaming plants of a gigantic *Alaria*, whose fronds sometimes extend to a length of 40 feet. Immediately beneath it, to the right, is the curiously perforated *Agarium Gmelini*, the singular perforations of which are indicated by small white patches.

To the right is the curious "flower-bearing" sea-weed known as the Sea Rose, *Constantinea Rosa marina*, the flower-like growth of which, combined with the pink colour of its seeming flowers, is very remarkable.

In front, and rather to the right of the last, is a dark mass of the splendid *Iridæa Mertensiana*, the dark velvety masses of which, of a deep crimson colour, are often more than a foot across.

To the right of the last, in the corner, is one of the most beautiful of the ulvæ, *Ulva fenestrata*, a name which may be popularised as the "windowed" ulva, in allusion to its extremely perforated character, the openings being of considerable size, and often separated from each other only by the slenderest divisions, thus forming a kind of vegetable lace-work.



A RUSSIAN OFFICIAL ATTENDED BY A SOLDIER COLLECTING ALGÆ ON THE SHORES OF THE NORTH PACIFIC.

every year several small vessels are sent from Jersey to the coast of Brittany, to fetch cargoes of sea-weeds for the farmers of that island.'

The largest of indigenous sea-weeds are the *Laminaria saccharina* and *digitata*, or the sugary and fingered oar-weeds. Their stout woody stems, and broad tough glossy leaves of dark olive-green, often twelve or fourteen feet long, must be familiar to every one who has sojourned on the coast. When gliding over their submerged groves in a boat, their great fronds floating like streamers in the water afford the interesting spectacle of a dense submarine thicket, through whose palm-like tops the fishes swim in and out, emulating in activity the birds of our forests.

But our native oar-weeds, large as they seem with regard to the other fuci among which they grow, are mere pygmies when compared with the gigantic species which occur in the colder seas.

None of the members of this family grow in the tropical waters, but they extend to the utmost polar limits, and seem to increase in size and multiplicity of form as they advance to the higher latitudes. The northern hemisphere has generally different genera from the southern. To the former belong the gigantic Alarias with their often forty feet long and several feet broad fronds, the singularly perforated Thalassophyta, and the far-spreading Nereocystis, which is only found in the Northern Pacific; while the genera Macrocystis and Lessonia are denizens of the Southern Ocean.

In the numerous channels and bays of Tierra del Fuego, the enormous and singular *Macrocystis pyrifera* is found in such incredible masses as to excite the astonishment of every traveller. "On every rock," says Mr. Darwin, perhaps the best observer of nature that ever visited those dreary regions, and certainly their most poetical describer, "the plant grows from low-water mark to a great depth, both on the outer coast and within the channels. I believe, during the voyages of the Adventure and Beagle, not one rock near the surface was discovered which was not buoyed by this floating weed. The good service it thus affords to vessels navigating near this stormy land is evident, and it certainly has saved many a one from being wrecked. I know few things more surprising than to see this plant growing and

flourishing amidst those great breakers of the western ocean, which no mass of rock, let it be ever so hard, can long resist. The stem is round, slimy, and smooth, and seldom has a diameter of so much as an inch. A few taken together are sufficiently strong to support the weight of the large loose stones to which in the inland channels they grow attached; and some of these stones are so heavy, that when drawn to the surface they can scarcely be lifted into a boat by one person."

"Captain Cook, in his second voyage says, that 'at Kerguelen's Land some of this weed is of most enormous length, though the stem is not much thicker than a man's thumb. I have mentioned that, on some of these shoals on which it grows, we did not strike ground with a line of twenty-four fathoms; the depth of water, therefore, must have been greater. And as this weed does not grow in a perpendicular direction, but makes a very acute angle with the bottom, and much of it afterwards spreads many fathoms on the surface of the sea, I am well warranted to say that some of it grows to the length of sixty fathoms and upwards.'

"Certainly at the Falkland Islands, and about Tierra del Fuego, extensive beds frequently spring up from ten and fifteen fathoms water. I do not suppose the stem of any other plant attains so great a length as 360 feet, as stated by Captain Cook. Its geographical range is very considerable; it is found from the extreme southern islets near Cape Horn, as far north on the eastern coast as lat. 43°, and on the western it was tolerably abundant, but far from luxuriant, at Chiloe, in lat. 42°. It may possibly extend a little further northward, but is soon succeeded by a different species.

"We thus have a range of 15° in latitude, and as Cook, who must have been well acquainted with the species, found it at Kerguelen's Land, no less than 140° in longitude.

"The number of living creatures, of all orders, whose existence intimately depends on the kelp, is wonderful. A large volume might be written, describing the inhabitants of one of these beds of sea-weed. Almost every leaf, except those that float on the surface, is so thickly incrusted with corallines as to be of a white colour. We find exquisitely delicate structures, some inhabited by simple hydra-like polypi, others by more organised kinds

and beautiful compound ascidiæ. On the flat surfaces of the leaves, various patelliform shells, trochi, uncovered mollusks, and some bivalves are attached. Innumerable crustacea frequent every part of the plant. On shaking the great entangled roots, a pile of small fish, shells, cuttle-fish, crabs of all orders, sea-eggs, star-fish, beautiful holothuriæ (some taking the external form of the nudibranch mollusks), planariæ, and crawling nereidous animals of a multitude of forms, all fall out together. Often as I recurred to a branch of the kelp, I never failed to discover animals of new and curious structure. In Chiloe, where, as I have said, the kelp did not thrive very well, the numerous shells, corallines, and crustacea were absent, but there yet remained a few of the Flustraceæ, and some compound ascidiæ; the latter, however, were of different species from those in Tierra del Fuego. We here see the fucus possessing a wider range than the animals which use it as an abode.

"I can only compare these great aquatic forests of the southern hemisphere with the terrestrial ones in the intertropical regions. Yet, if the latter should be destroyed in any country, I do not believe nearly so many species of animals would perish, as under similar circumstances would happen with the kelp. Amidst the leaves of this plant numerous species of fish live, which nowhere else would find food or shelter; with their destruction the many cormorants, divers, and other fishing-birds, the otters, seals, and porpoises, would soon perish also; and lastly the Fuegian savage, the miserable lord of this miserable land, would redouble his cannibal feast, decrease in numbers, and perhaps cease to exist."

For many a day's sail before reaching Cape Horn, large bundles of the macrocystis detached by the storm announce to the navigator that he is approaching the desolate coasts of Tierra del Fuego.

"We succeeded," says Professor Meyen, in his *Reise um die Welt*, "in getting hold of one of these floating islands, which, amid loud acclamations, was hauled upon deck by the exertions of five men. It was quite impossible to disentangle the enormous mass; we could only detach, to the length of about sixty feet, what we considered to be the chief stem; the branches were from thirty to forty feet long, and as thick as the principal trunk from which they sprang. We estimated the total length

of the plant at about two hundred feet; the pear-shaped air vessels at the basis of the leaves were often six or seven inches long, and the leaves themselves measured seven or eight feet. On these swimming fucus-islands lived a vast multitude of various animals; thousands upon thousands of barnacles and sertulariæ, of crustaceans and annelides.

"The admiration which the gigantic sea-weeds of Tierra del Fuego excited in our minds equalled that which had been raised by the exuberant vegetation of the virgin forests of Brazil. One single plant of the *Macrocystis pyrifera* would suffice, like one of the mammoth-trees of those luxuriant woods, to cover a large space of land with its leaf-like substance. The quantity of small algæ, of sertularias, cellarias, and other minute animals dwelling on these swimming islands, surpasses in variety the multitude of parasitical plants bedecking the trees in a tropical forest. It seems as if, in these desolate and dreary regions, the generative powers of the planet were solely confined to the gigantic growth of submarine vegetation."

On the rocky coasts of the Falkland Islands are found no less astonishing masses of enormous sea-weeds, chiefly belonging to the genera Macrocystis, Lessonia, and Durvillea. Rent from the rocks to which they were attached, and cast ashore, they are rolled by the heavy surf into prodigious vegetable cables, much thicker than a man's body and several hundred feet long. Many of the rarest and most beautiful algæ may be here discovered, which have either been wrenched from inaccessible rocks far out at sea, along with the larger species, or have attached themselves parasitically to their stems and fronds. Many of them remind the botanist, by some similarity of form, of the sea-weeds of his distant home, while others tell him at once that he is far away in another hemisphere. The gigantic lessonias particularly abound about these islands. Their growth resembles that of a tree. The stem attains a height of from eight to ten feet, the thickness of a man's thigh, and terminates in a crown of leaves two or three feet long, and drooping like the branches of a weeping-willow. They form large submerged forests, and, like the thickets of the macrocystis, afford a refuge and a dwelling to countless sea animals.

A similar abundance of colossal algæ is found in the Northern Pacific, about the Kurile and Aleutic Islands, and along the

deeply indented and channel-furrowed north-west coast of America.

Thus the *Nereocystis lutkeana* forms dense forests in Norfolk Bay and all about Sitcha. Its stem, resembling whipcord, and often above 300 feet long, terminates in a large air-vessel, six or seven feet long, and crowned with a bunch of dichotomous leaves, each thirty or forty feet in length. Dr. Mertens assures us that the sea-otter, when fishing, loves to rest upon the colossal air-vessels of this giant among the sea-weeds, while the long tenacious stems furnish the rude fishermen of the coast with excellent tackle. The growth of the nereocystis must be uncommonly rapid, as it is an annual plant, and consequently develops its whole gigantic proportions during the course of one brief summer.

Before proceeding to the third chief group of marine plants, the red sea-weeds, or Rhodosperms, I must mention the enormous fucus banks, or floating meadows of the Atlantic, which form undoubtedly one of the greatest wonders of the ocean.

We know that the mighty Gulf Stream, which rolls its indigo-blue floods from America to the opposite coasts of the Old World, flows partly southwards in the neighbourhood of Azores, and is ultimately driven back again to America. In the midst of these circuitous streams, from 22° to 36° N. lat., and from 35° to 65° W. long., extends a sea without any other currents than those resulting from the temporary action of the winds. This comparatively tranquil part of the ocean, the surface of which surpasses at least twenty times that of the British Isles, is found more or less densely covered with floating masses of *Sargassum bacciferum.* Often the sea-weed surrounds the ship sailing through these savannas of the sea, in such quantities as to retard its progress, and then again hours may pass when not a single fucus appears. While Columbus was boldly steering through the hitherto unknown fields of the Sargasso Sea, the fears of his timorous associates were increased by this singular phenomenon, as they believed they had now reached the bounds of the navigable ocean, and must inevitably strike against some hidden rock, if their commander persevered in his audacious course.

It is an interesting fact that the Sargasso Sea affords the most remarkable example of an aggregation of plants belonging to one single species. Nowhere else, according to Humboldt, neither in

the savannas of America, nor on the heaths or in the pine forests of Northern Europe, is such a uniformity of vegetation found as in those boundless maritime meadows.

"The masses of sea-weeds," says Meyen, "covering so vast an extent of ocean have ever since the time of Columbus been the object of astonishment and inquiry. Some navigators believe that they are driven together by the Gulf Stream, and that the same species of Sargassum plentifully occurs in the Mexican Sea; this is however perfectly erroneous.

"Humboldt was of opinion that this marine plant originally grows on submarine banks, from which it is torn by various forces; I for my part have examined many thousands of specimens, and venture to affirm that they never have been attached to any solid body. Freely floating in the water, they have developed their young germs, and sent forth on all sides roots and leaves, both of the same nature."

Thus the Sargassum seems to be the indigenous production of the sea where it appears, and to have floated there from time immemorial. Its swimming islands afford an abode and nourishment to a prodigious amount of animal life. They are generally covered with elegant sertularias, coloured vorticellas, and other strange forms of marine existence. Various naked or nudibranchiate mollusks and annelides attach themselves to the fronds, and afford nourishment to hosts of fishes and crustaceans, the beasts of prey of this little world.

Similar aggregations of sea-weeds are also met with in the Indian and Pacific Oceans, in the comparatively tranquil spaces encircled by rotatory currents. Their rare occurrence on the surface of the sea may serve as a proof of the restless motion of its waters. Were the ocean not everywhere intersected by currents, it would most likely be covered with sea-weeds, opposing serious, if not invincible obstacles to navigation.

The *Red* sea-weeds, Rhodosperms or Florideæ, are by far the most numerous in species, and undoubtedly the most beautiful and perfect of all the algæ. They love neither light nor motion, and generally seek the shade of larger plants on the perpendicular sides of deep tide-pools removed from the influences of the tides and gales. They mostly grow close to low-water mark, and are to be seen only for an hour or two at the spring-tides, during which, as is well known, the deepest ebbs take place. To this group be-

long the wonderfully delicate polysiphonias, callithamnias, plocamias, and delesserias, whose elegant rosy scarlet or purple leaves are the amateur's delight, and when laid out on paper resemble the finest tracery, defying the painter's art to do justice to their beauty. It likewise numbers among its genera the chalky corallines and nullipores, which on account of the hardness of their substance were formerly considered to be polyps, but whose true nature becomes apparent on examining their internal structure.

The *Chondrus crispus*, or Carrigeen, which grows in such vast quantities on the coasts of the British Isles, also belongs to the rhodosperms, though when growing, as it frequently does, in shallow tide-pools, exposed to full sunlight, its dark purple colour fades into green or even yellowish white. When boiled it almost entirely dissolves in the water, and forms on cooling a colourless and almost tasteless jelly, which of late years has been largely used in medicine as a substitute for Iceland moss. Similar nutritious gelatines, which also serve for the manufacture of strong glues, are yielded by other species of rhodosperms, among others by the *Gracillaria spinosa* of the Indian Ocean, which the Salangana (*Hirundo esculenta*), a bird allied to the swallow, is said principally to use for the construction of her edible nest.

The steep sea-walls along the south coast of Java are clothed to the very brink with luxuriant woods, and screw-pines strike everywhere their roots into their precipitous sides, or look down by thousands from the margin of the rock upon the unruly sea below. The surf of incalculable years has worn deep caves into the chalk cliffs, and here the Salangana builds her nest. Where the sea is most agitated whole swarms are observed flying about, and purposely seeking the thickest wave-foam. From a projecting cape, on looking down upon the play of waters, may be seen the mouth of the cave of Gua Rongkop, sometimes completely hidden under the waves, and then again opening its black recesses, into which the swallows vanish, or from which they dart forth with the rapidity of lightning. While at some distance from the coast the blue ocean sleeps in undisturbed repose, it never ceases to fret and foam against the foot of the mural rocks, where the most beautiful rainbows glisten in the eternally rising vapours.

Who can explain the instinct which prompts the birds to glue their nests to the high dark vaults of those deep, and apparently so inaccessible, caverns? Did they expect to find them a safe retreat from the persecutions of man? Then surely their hopes were vain, for where is the refuge to which his insatiable avidity cannot find the way? At the cavern of Gua-gede, the brink of the precipitous coast lies eighty feet above the level of the sea at ebb-tide; the wall first bends inwards, and then, at a height of twenty-five feet from the sea, throws out a projecting ledge which is of great use to the nest-gatherers, serving as a support for a rotang ladder let down from the cliff. The roof of the cavern's mouth lies only ten feet above the sea, which, even at ebb-tide, completely covers the floor of the cave, while at flood-tide the opening of the vast marine grotto is entirely closed by every wave that rolls against it. To penetrate into the interior is thus only possible at low water, and during very tranquil weather; and even then it could not be done, if the rugged roof were not perforated and jagged in every direction. The boldest and strongest of the nest-gatherers wedges himself firmly in the hollows, or clings to the projecting stones, while he fastens rotang ropes to them, which then depend four or five feet from the roof. To the lower ends of these ropes long rotang cables are attached, so that the whole forms a kind of suspension bridge throughout the entire length of the cavern, alternately falling and rising with its inequalities. The cave is 100 feet broad and 150 long as far as its deepest recesses. If we justly admire the intrepidity of the St. Kildans, who, let down by a rope from the high level of their rocky birthplace, remain suspended over a boisterous sea, we must needs also pay a tribute of praise to the boldness of the Javanese nest-gatherers. Before preparing their ladders for the plucking of the birds' nests, they first offer solemn prayers to the goddess of the south-coast, and sometimes deposit gifts on the tomb where the first discoverer of the caverns and their treasures is said to repose. Thus in all zones and in every stage of civilisation, man is directed by an inward voice to seek the protection of the invisible powers when about to engage in a great and perilous undertaking.

As I have already mentioned, the Salangana builds her nest of sea-weeds, which she softens in her stomach and then disgorges. During its construction new layers, which soon grow hard in the air, are continually deposited on the margin, until it has

attained the proper size. When gathering time approaches, some of the pluckers daily visit the cavern to examine the state of the brood. As soon as they find that most of the young are beginning to be provided with feathers, their operations commence. These nests form the first quality; those in which the young are still completely naked, the second; while those which only contain eggs, and are consequently not yet ripe, rank third. The nests with young whose feathers are completely developed are over-ripe, black, and good for nothing. All the young and eggs are thrown into the sea. The gathering takes place three times a year; the birds breed four times a year. In spite of these wholesale devastations their numbers do not diminish; as many of the young have no doubt flown away before the day of execution, or other swallows from still unexplored caverns may fill up the void. In this manner about 50 piculs are annually collected, which the Chinese pay for at the rate of 4000 or 5000 guilders the picul. Each picul contains on an average 10,000 nests. Dividing these 500,000 nests among three gatherings, and reckoning two birds to each nest, we find that more than 333,000 swallows inhabit at the same time the Javanese coast caverns.

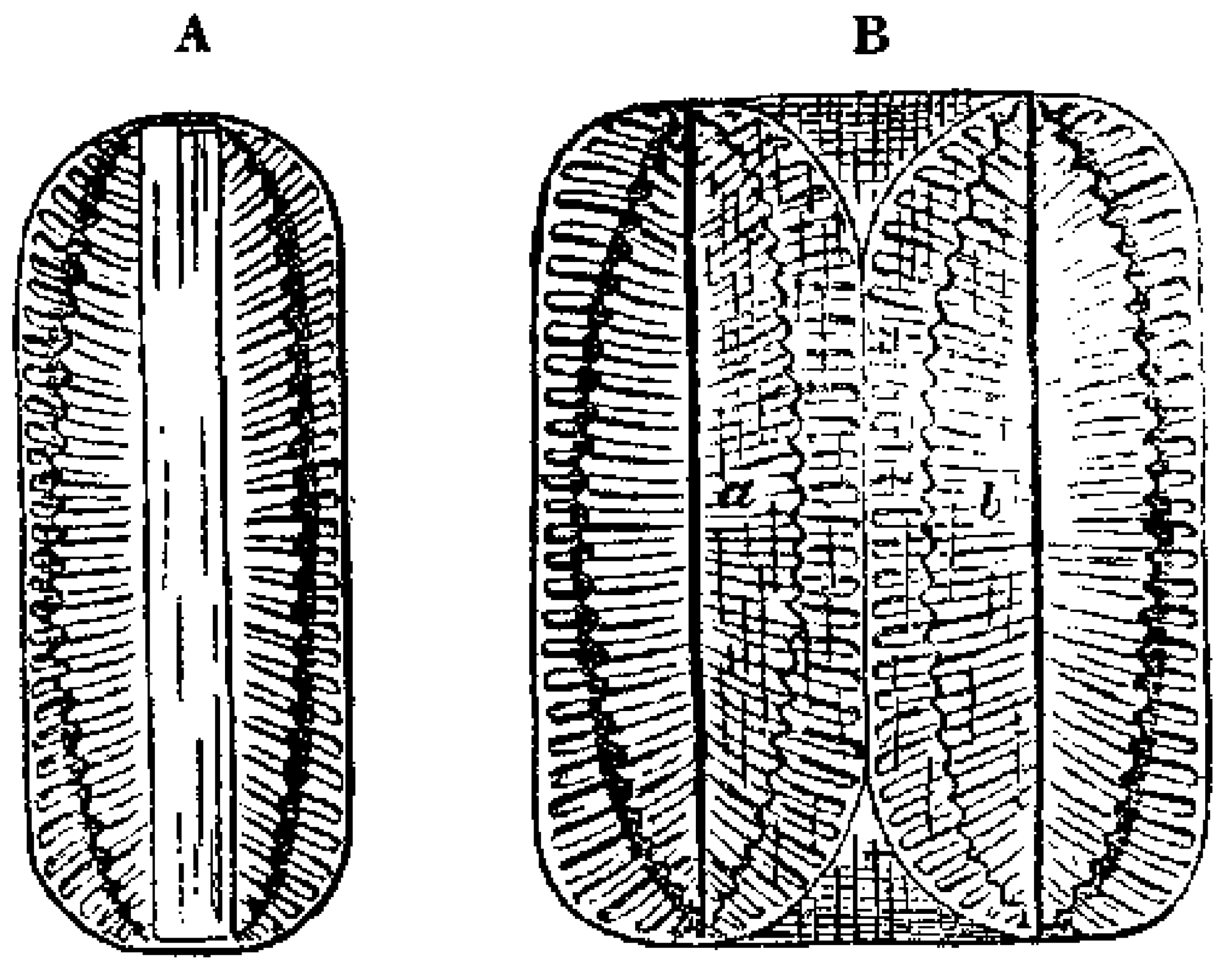
In the interior of the island, in the chalkstone grottos of Bandong, the Salangana also breeds, but in far inferior numbers, as here the annual collection amounts on an average to no more than 14,000 nests. In these inland caves swallows and bats reside together, but without disturbing each other, as the former when not breeding leave their caverns at sunrise, disappear in the distance, and only return late in the evening, when the bats are already enjoying their vespertine or nocturnal flight.

In Sumatra and some other islands of the Indian archipelago, birds' nests are likewise collected, but nowhere in such numbers as in Java. They are brought to the Chinese market, where they are carefully cleaned before being offered for sale to the consumer. The addition of costly spices renders them one of the greatest delicacies of Chinese cookery, but as for themselves they are nothing better than a fine sort of gelatine.

The Japanese have long been aware that these costly birds' nests are in fact merely softened algæ. They consequently pulverise the proper species of sea-weeds, which are abundantly found on

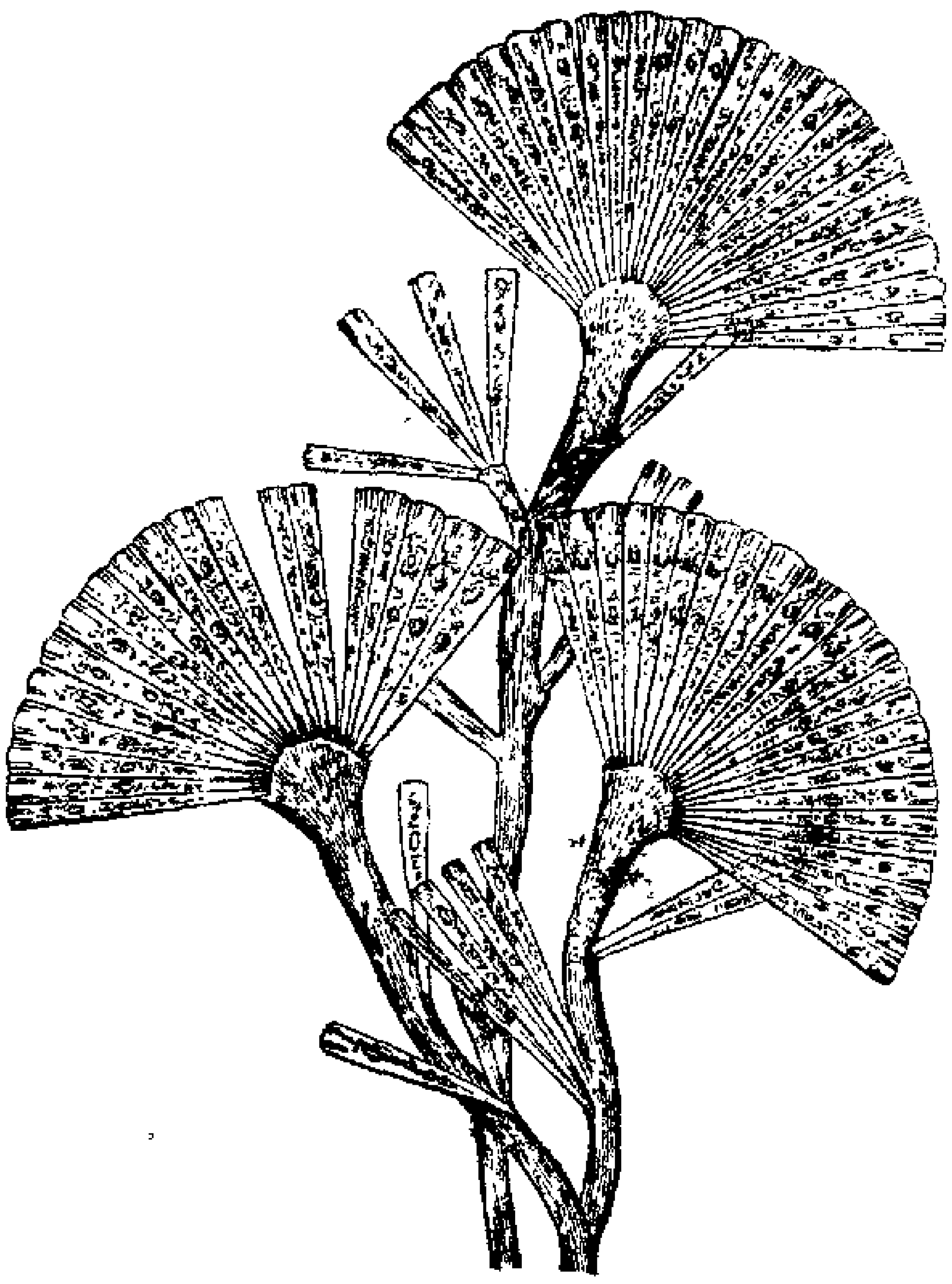
their own coasts, boil them to a thick jelly, and bring them to market under the name of *Dschin-schan*, as artificial birds'-nests. The Dutch call it Agar-agar, and make great use of it; simple boiling sufficing to convert the dried substance into a thick uniform jelly, which is both nourishing and easy of digestion. Thus we see that the algæ, which the Romans considered so perfectly worthless that, when they wished to express their utter contempt of an object, they declared it to be still viler than the vile sea-weed, are by no means deserving of so hard a sentence. Man himself might be much more justly reproached for neglecting the abundant stores of nourishment which nature has gratuitously provided for him on all flat and rocky coasts. For not only the species I have mentioned are eatable, but also some of the commonest fuci of our seas (*Fucus nodosus, F. vesiculosus, Laminaria saccharina*), as well as the gigantic alarias and durvilleas of the colder oceanic regions. And yet how rare is their use, notwithstanding the increasing wants of a rapidly growing population!

Besides the larger forms of vegetation, the ocean contains a vast number of microscopical plants. Among these the most remarkable are the Diatomaceæ, simple vegetable cells enclosed in a flinty envelope, consisting of two plates closely applied to each other like the two valves of a mussel. The forms of these minute organisms are no less curious than those of the Foraminifera, for they exhibit regular mathematical figures, and their surface is often most delicately sculptured. Multiplying by spontaneous fissure, many of the Diatoms are met with entirely free after the process of duplicative subdivision has once been completed, while others, such as the Licmophora, or Fan-bearer, an elegant native species, habitually remain coherent one to another, producing clusters or filaments of various shapes, connected by a gelatinous investment or by a stalk-like appendage, which serves to attach them to other plants or to stones and to pieces of wood. Though individually



Surirella constricta.
A. Front view. B. Binary subdivision.—(Highly magnified.)

invisible to the naked eye, they appear, when thus congregated, as patches of a green or brownish slimy mass, or as little glittering tufts a line or two in height. Some of their numerous species are natives of fresh water, but by far the majority are denizens of the sea, where they are found from the equator to the poles. The brown scum floating upon the surface of the antarctic waters near the mighty ice barrier which arrested Sir James Ross's progress to the south pole was found to consist almost solely of Diatomaceæ, and they are equally abundant in the Arctic Ocean.



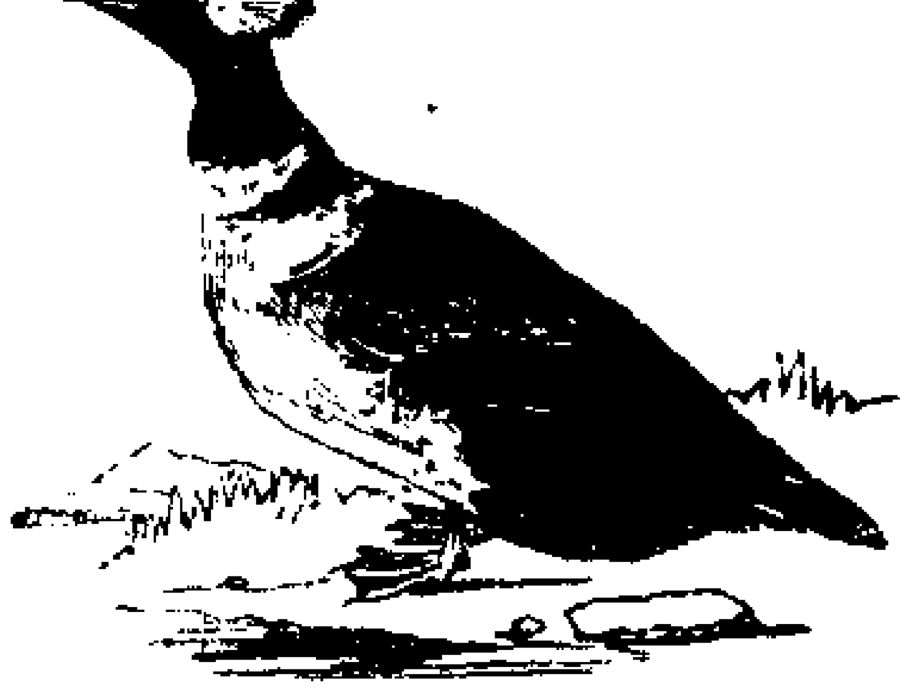
Licmophora flabellata.
(Highly magnified.)

It is remarked by Dr. Hooker that the universal presence of this invisible vegetation throughout the South Polar Seas is a most important feature, since there is a marked deficiency in this region of higher forms of vegetation, so that without the Diatoms there would neither be food for aquatic animals nor (if it were possible for these to maintain themselves by preying on one another) could the ocean waters be purified of the carbonic acid which animal respiration would be continually imparting to it. Thus it is not in vain that they abound in the most inhospitable seas, where but for them no sea-bird would flap its wings, and no dolphin dart through the desert waters.

From the indestructible nature of their flinty coverings the Diatoms play a no less conspicuous part in the geological history of our globe than the calcareous Foraminifera.

Extensive rocky strata, chains of hills, beds of marl—once deposited at the bottom of the ocean, and raised by subsequent changes of level from the depth of the waters—contain the remains of these little plants in greater or less abundance. No country is destitute of such monuments, and in some they con-

stitute the leading features in the structure of the soil. Under the whole city of Richmond, in Virginia, and far beyond its limits, over an area of unknown extent, they form a stratum of eighteen feet in thickness, and similar deposits are found to alternate in the neighbourhood of the Mediterranean with calcareous strata chiefly composed of Foraminifera. At first sight it may seem a gross exaggeration to attribute so vast an agency to beings individually so minute, but when we recollect how quickly they multiply by division, and how their activity dates from the first dawn of organic creation, their architectural powers no longer seem incredible. In forty-eight hours a single diatom may multiply to 8,000,000, and in four days to 140,000,000,000,000, when the silicious coverings of its enormous progeny will already suffice to fill up a space of two cubic feet. No wonder, then, that during the course of ages these microscopic plants have been able to form prodigious strata wherever circumstances favoured their propagation. In no case is the power of numbers more forcibly exemplified, for where can we find results more vast, proceeding from the infinite multiplication of the smallest individuals, than that whole tracts of country should literally be built up of the skeletons of Foraminifera and Diatomaceæ?



Hooded Merganser.

CHAP. XX.

THE GEOGRAPHICAL DISTRIBUTION OF MARINE LIFE.

The Dependence of all created Beings upon Space and Time.—The Influences which regulate the Distribution of Marine Life.—The four Bathymetrical Zones of Marine Life on the British Coasts, according to the late Professor Edward Forbes of Edinburgh.—Abyssal Animals.—*Bathybius Haeckelii.*—Deep-Sea Sponges and Shell-Fish.—Vivid Phosphorescence of Deep-Sea Animals.—Deep-Sea Shark Fishery.—The "Challenger."

THE wanderer to distant lands sees himself gradually surrounded by a new world of animals and plants. On crossing the Alps, for instance, the well-known vegetable forms of our native country leave us one after the other; the beech, the fir, the oak, no longer meet the eye, or appear but rarely, and of more stunted growth, while in their stead citron and olive-trees decorate the landscape; and finally, on the shores of the Mediterranean the world of palms begins to disclose its beauties.

Thus during a long journey our early companions drop off one after the other, until at last we see ourselves surrounded by a crowd of new associates, who were strangers to us at the beginning of our pilgrimage.

We may cross the earth from pole to pole, or follow the sun in his diurnal course; in all directions, from north to south and from east to west, Nature will be found to change her garments as we proceed, and never to resume again those she has once cast off. The plants and animals of the temperate and cold regions of the north are different from those of the analogous regions in the southern hemisphere; and in the tropical zone each part of the world nourishes its peculiar inhabitants.

Similar changes meet our eye on ascending from the plains to the summits of high mountains. At the foot of Etna flourishes the luxuriant vegetation of a warmer sky, the palmetto (*Chamærops humilis*) and the pomegranate, even the cotton shrub and the sugar-cane; higher up, the cool shade of magnificent chestnut woods refreshes our path; then follows the stately oak; until finally we attain the dreary height where all vegetation ceases in the

dreadful cold of an eternal winter. With every thousand feet we rise above the level of the sea, we seem to have advanced nearer and nearer to the pole.

This wonderful change of form, which decorates the various regions of the earth with such an endless variety of organised existence, alike prevails in the realms of ocean. Here we find every larger sea-basin nourishing its peculiar inhabitants, and discover at various vertical distances beneath the surface of the sea, changes in organic nature similar to those we observed at different distances above its level.

Thousands of extinct animal and vegetable forms, which have successively flourished and disappeared, teach us the important lesson, that all created beings are made but for a season. It is only during a determined epoch of planetary life that each genus or species finds that combination of outward circumstances, under which it is able to attain its highest perfection. But imperceptibly, in the course of ages, the external world modifies its nature; families once flourishing in a different atmosphere decline and wither; they are no longer able to maintain themselves against new forms of life starting up in all the vigour of youth, and disappear from the scene, supplanted by races which must one day vanish in their turn.

Organic life is no less dependent on place than it is on time. Of the numberless animal and vegetable forms that people the earth, each finds in only one spot the scene of its greatest size and its greatest profusion. Some endowed with a more pliable or energetic nature occupy a large space upon the surface of the globe; we find them in the enjoyment of healthy existence scattered far and wide over whole hemispheres, while others are obliged to content themselves with the narrowest birthplace, and are not seldom confined to a single bay, or a single mountain side.

A great part of the magic charm of nature is owing no doubt to this deep and mysterious connexion between the soil and its productions. Here all is harmony; we feel it in our hearts; and our eye delights in the consonance of forms and colours, as our ear in the concord of sweet sounds. And where is the mortal artist whose paintings could rival the ever-changing panorama which the Master of all worlds unfolds through all zones, from pole to pole? His pictures constantly fade away; but they are

perpetually succeeded by new creations of equal beauty. Happy the man whose eye is open to their charms! Every ramble through the woods and fields is to him a banquet of pure and inexhaustible delight.

The causes which confine the life of animals and plants to circumscribed localities are in many cases easily to be traced. The warmth or coldness of the sea, resulting from currents, geographical position, and depth; tranquil or disturbed, pure or troubled waters; abundance or scarcity of food, solidity or softness of the ground, sufficiently explain why many species of marine animals appear in some places in considerable numbers, while in others they are totally wanting. A superficial view of their organisation often shows us at once the physical properties their *habitat* must necessarily possess. By looking at a fucus we immediately see whether it requires the protection of tranquil waters, or is able to bid defiance to the floods; whether it is made to anchor upon the rock, or to sink its roots into a more yielding soil.

In many cases, however, the causes which regulate the distribution of the sea-animals are still enveloped in darkness, and we no more know why the tropical seas bring forth in some places numerous coral-reefs, and none at all in other to all appearance just as favourably situated localities, than we do why the tea-plant is confined to a small corner of Asia, or the Peruvian cinchonas to a narrow girdle on the Andes.

Evidently, besides the influences known to us, there are many other hidden ones at work, whose conflicting powers draw round every living creature a mysterious circle, whose bounds it is unable to transgress. Their discovery belongs to the future, and certainly forms one of the most interesting subjects for the naturalist's inquiries.

The geographical distribution of the terrestrial plants and animals is undoubtedly much easier to be ascertained than that of the denizens of the ocean. The naturalist is able to climb the highest mountains beyond the extreme limit of vegetation, and far above their most towering peaks his eye, piercing the transparent atmosphere, sees the condor soar in solitary majesty; he can wander through the deepest glens, or even, penetrating into the bowels of the earth, examine and collect the forms of the subterranean flora; but it has not been given him to peram-

bulate the submarine meads, or to force his way leisurely through dense thickets of algæ, and explore their hidden wonders.

Yet, in spite of these natural impediments, his inventive genius, fired by his insatiable avidity of knowledge, has given him the means of interrogating the abyss, and partly raising the veil behind which marine life conceals its secret operations. Armed with a dredge, he fetches from the bottom of the sea plants, polypi, mollusks, and annelides, and learns to distinguish the various depths assigned for their abode; or he puts on the helmet of the submarine diver, and passes whole hours in collecting and observing beneath the clear waters of the sea; or he drops the plummet hundreds of fathoms deep into the ocean, and draws it up again coated with specimens of corals or Foraminifera.

To the late Professor Edward Forbes of Edinburgh science is indebted for the first investigations of this nature that have been undertaken on a greater scale; and, to give the reader some idea of the causes which regulate the distribution of marine life, I cannot do better than cite a few of the general results of that eminent naturalist's researches.*

As the animals and plants of the land are grouped together into distinct zoological and botanical provinces, so likewise is the population of the sea gathered into geographical groups, which, though well marked in their more central and most developed portions, imperceptibly merge at their margins into those of neighbouring realms. "These submarine provinces have a more or less direct correspondence with those of the neighbouring lands, though sometimes they differ very considerably from the latter in their extent; since the physical features which may constitute boundaries in the one, may not be sufficiently extended or developed in the other to impede the spread of peculiar species of animals or plants. Marine creatures, owing to their organisation and the transporting powers of the element in which they live, are much more capable of diffusion, as a whole, than the terrestrial organisms; hence we should expect to find the regions they respectively inhabit, beneath the waves, of much vaster dimensions than those occupied by similar geogra-

* Natural History of the European Seas, by the late Professor E. Forbes. Edited by R. Godwin Austen, 1859.

phical assemblages of their terrestrial brethren; and such is to a great extent true. Nevertheless, the inequalities of the sea-bed, the modifications of the temperature of the ocean produced by currents pouring through it like mighty rivers, the projection of promontories, and the more important interruptions caused by the great gulfs and abysses of the deep, or by vast and comparatively desert tracts of unprolific sand, which in many places are spread out in extensive shallows, are all-powerful influences, determining their diffusion within certain and more or less defined limits."

The *structure of the coast,* as far as the mineral character of its rocks is concerned, may seriously affect the distribution of particular tribes. Since many shell-fish, for instance, bore only in limestone or rocks containing abundance of lime, a very ordinary difference in the nature of the strata must necessarily determine their presence or absence.

The *outline of a coast* has also great influence in regulating the diffusion of species. A much indented region is very favourable to submarine life; a straight coast-line, exposed to the full rolling of the surf, is usually unfavourable, though there are a few creatures which delight in the dash of the waves, and hardily, though some of them are small and exceedingly delicate, brave the full force of the ocean storms, reminding us, as Mr. Godwin Austen quaintly remarks, " of those sturdy people, not uncommon in this stormy life, who thrive best in troubles, and feel happiest under conditions that make most men miserable."

The *nature of the sea-bottom,* according as it consists of mud, sand, gravel, nullipore, broken shells, loose stones, or rock, determines, to a great extent, the presence or absence of peculiar forms of shell-fish and other invertebrata, and of fish also, since the distribution of the food regulates that of the devourers.

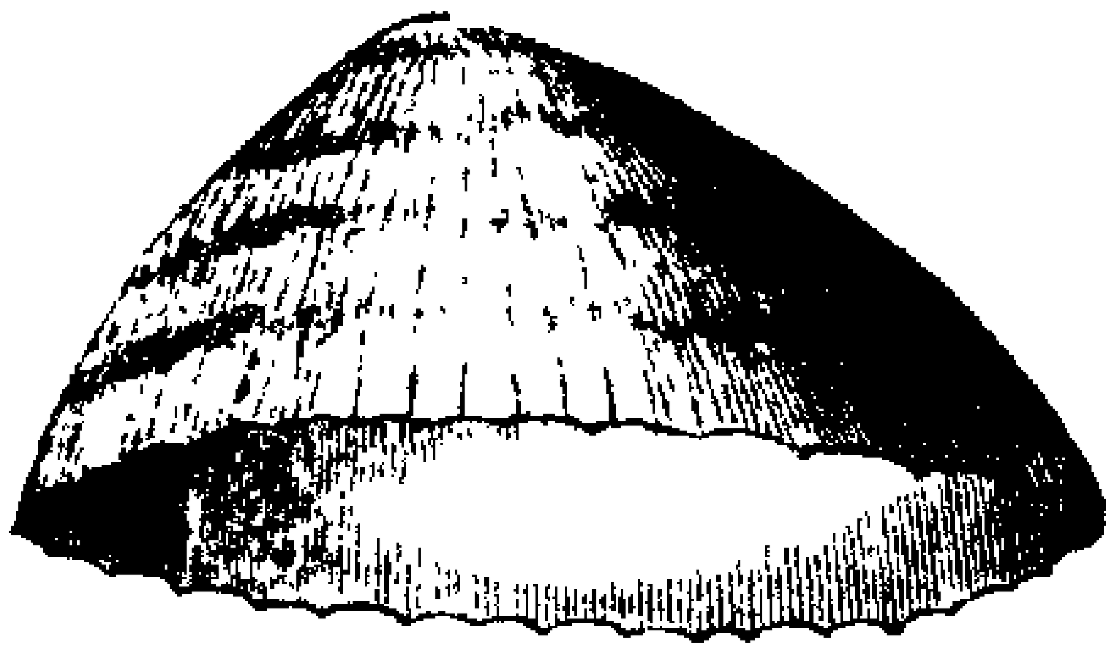
The *rise and fall of the tides* are most important in determining the presence or absence of the species inhabiting the littoral zone. The *currents,* besides their agency as modifiers of climate, act as means of transport, by carrying the germs and larvæ of numerous creatures from region to region.

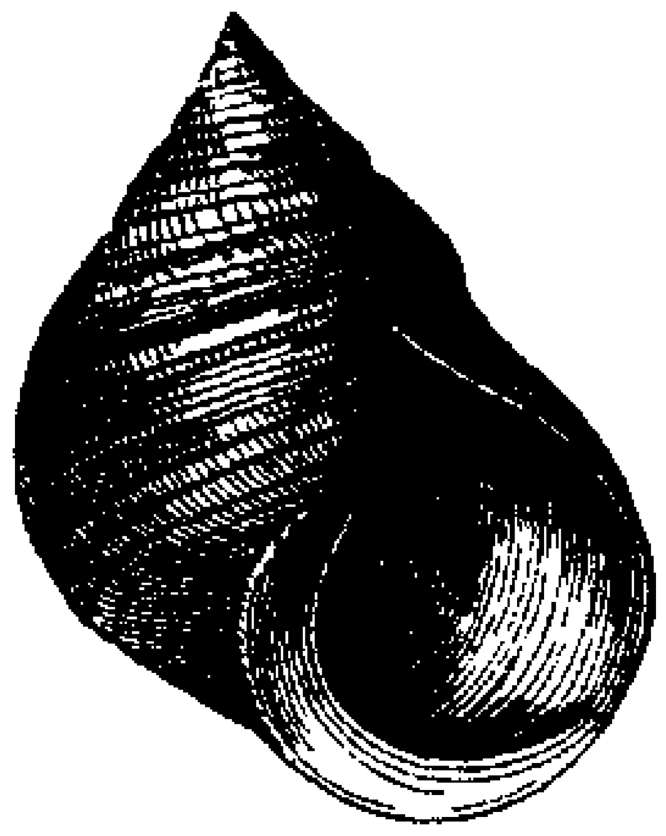
The *influence of climate* is conspicuously manifested in the diminution of the number of genera and species as we proceed northwards to the Icy Ocean.

The *composition of the waters* has also a most important effect on the distribution of aquatic animals, as the degree of saltness or freshness determines the presence or absence of numerous forms of both fishes and invertebrate animals; and last, not least, the *influence of depth*, in which *pressure* and the *diminution of light* are doubtless important elements, is everywhere manifest over the ocean, "for everywhere we find creatures, whether animal or vegetable, distributed in successive belts or regions, from high-water mark down to the deepest abysses from which living beings have been drawn up. Peculiar types inhabit each of the zones, and are confined within their destined limits, whilst others are common to two or more, and not a few appear capable of braving all bathymetrical conditions. Nevertheless, so marked is the appearance of the inhabitants of any given region of depth, that the sight of a sufficient assemblage of them from any one locality will enable the naturalist at once to declare the soundings within certain limits, and without the aid of line or plummet."

In the British seas *four* distinct and well-marked zones of life succeed each other in vertical extension. The first of these is the *littoral zone*, equivalent to the tract between tide-marks, but quite as manifest in those portions of the coast-line where the tides have a fall of only a foot or two, or even less, as in districts where the fall is very great. This important belt, which again forms four subdivisions, and is inhabited by animals and plants capable of enduring periodical exposure to the air, to the glare of light, the heat of the sun, the pelting of rain, and often to being more or less flooded with fresh water when the tide has receded, claims many genera as well as species peculiar to itself. "The verge of continual air is generally distinguished by the abundant presence of *Fucus canaliculatus*, among whose roots may be found crowds of small varieties of the periwinkle, called *Littorina rudis*, which indeed range out of the water considerably, and may be found adhering to rocks many feet above high-water mark." The second subregion is marked by the abundance of a small dark rigid seaweed, called *Lichina*, painting the rock sides as if with a dingy stripe. With it we find the larger forms of *Littorina rudis*, abundance of the common limpet (*Patella vulgata*), the common mussel (*Mytilus edulis*), and myriads of small seaside

barnacles, often striping the sea-wall in a broad white band. "Where the shore shelves a little, and rocky ledges decline gradually into the sea, the common mussel delights to live, firmly anchored by its byssal cable in the crevices of rocks or among masses of gravel, the pebbles of which are tied together by its silky filaments." The rock sides and the floors of transparent pools are here often thickly coated with a nullipore, forming a hard pale red crust. The region of half-tide forms a third subdivision of the littoral zone, and is exceedingly prolific in marine animals and plants. "Here we find *Fucus articulatus*, with its graceful even-edged rich brown fronds, mingled occasionally with the less elegant *Fucus nodosus*. Here limpets throng, and dog-periwinkles (*Purpura lapillus*) crawl observantly, seeking to bore more passive mollusks and extract their juicy substance. This is the home of the best of periwinkles, the large black *Littorina littorea*, gathered in thousands for the London market. On our western coasts we find it in company with the purple-striped top-shell (*Trochus umbilicatus*), and towards the south with the larger *Trochus crassus*. Here also sea-anemones love to expand their many-armed disks, often glowing with the most brilliant colours." A fourth sub-region succeeds, the lowest belt above low-water mark, and is distinguished by the presence of the black saw-toothed sea-weed (*Fucus serratus*), so much used in the packing of lobsters for market. On its fronds creeps the lowest in grade of the periwinkles, the variously tinted *Littorina neritoides*, exhibiting every colour in its obtuse and thickened shell.


Limpet.


Periwinkle.

"At the verge of low-water mark, immediately below it, whereever the coast is rocky, there are all round the British shores, within a space of a few inches, a remarkable series of more or less distinctly defined belts, each consisting of a different species of sea-weed. These in succession are, the *Laurencia pinnatifida* uppermost; then the green *Conferva rupestris;* then the

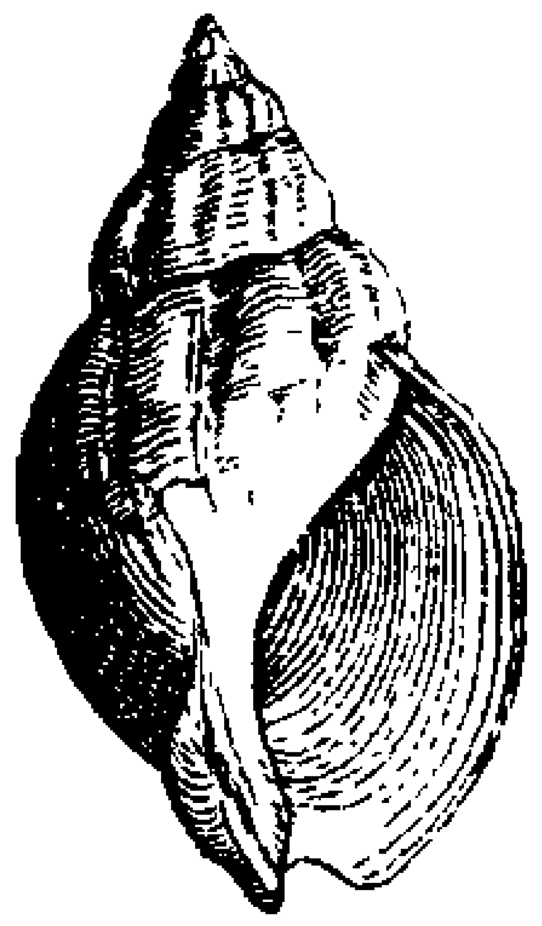
elegant and firm, often iridescent, fronds of *Chondrus crispus*; and, lowermost, the thong-weed or *Himanthalia lorea*."

Succeeding the shore-band, or littoral zone, we have the *region of the great laminaria or tangle forests*, or in sandy places the waving meadows of zostera, or grass-wrack. It extends from the edge of low water to a depth varying in different localities, but seldom exceeding fifteen fathoms, and is itself divided into sub-regions, marked by belts of differently tinted algæ. This zone above all others swarms with life, and is the chief residence of fishes, mollusks, crustaceans, and invertebrata of all classes, remarkable for brightness and variety of colouring. "Here," says Mr. Godwin Austen, "is the chosen haunt of the nudibranchiate mollusks, animals of exceedingly delicate texture, extraordinary shapes, elegance of organs, and vividness of painting. Their bodies exhibit hues of a brilliancy and intensity such as can match the most gorgeous setting of a painter's palette. Vermilion red, intense crimson, pale rose, golden yellow, luscious orange, rich purple, the deepest and the brightest blues, even vivid greens and densest blacks, are common tints, separate or combined, disposed in infinite varieties of elegant patterns, in this singular tribe. Our handsomest fishes are congregated here, the wrasses especially, some of which are truly gorgeous in their painting. Here are gobies and more curious blennies, swimming playfully among these submarine groves. Strange worms crawl serpent-like about their roots, and formidable crustacea are the wild beasts who prowl amid their intricacies. The old stalks, and the surfaces of the rocky or stony ground on which they usually grow, are incrusted like the trunks of ancient trees or faces of barren rocks with lichenous investments. But whereas in the air these living crusts are chiefly if not all of vegetable origin, in the sea they are more often constructed out of animal organisms. Some of them are sponges, others are true zoophytes, others polyzoa or bryozoa, beings that have proved to belong to the class of mollusks, however unlike they may seem to shellfish.

"In the middle and lower part of the Laminarian region around our shores the tangles become less plentiful as we descend, and at last become exceptional and disappear. But other sea-weeds are very abundant, especially those that delight in red or purple hues. Tender sea-mosses, exquisitely delicate

in form and colouring, abound. Where none of these are very plentiful, we often find the coral-weed or nullipore in vast quantities, and assuming many strange modifications of form. Among these vegetable corals numbers of shells and articulate animals delight to live, and probably not a few feed upon their stony fronds. The Lima, a shellfish related to the scallop, gathers the broken branches by means of prehensile tentacles, and constructs for itself a comfortable nest lined with a woven cloth of byssal threads. Numerous fishes resort to these rugged pastures in order to deposit their spawn among the gnarled branchlets."

To the laminarian succeeds the *coralline zone*, extending in most places some thirty fathoms or more. Plants, indeed, are rare, but here the horny plant-like sertularias love to rear their graceful feathery branches, and form miniature gardens of fairy-like delicacy and beauty; and here carnivorous mollusks, whelks above all, prowl in great numbers. Bivalves of remarkable elegance, especially clams and scallops, are found buried in multitudes beneath its gravels and muddy sands; and no less plentifully congregate the spider-crabs, with many other peculiar crustaceans. As a natural consequence of this well-furnished table, fishes abound, and many of our deep sea and white fisheries owe their value to the zoological features of the coralline zone.

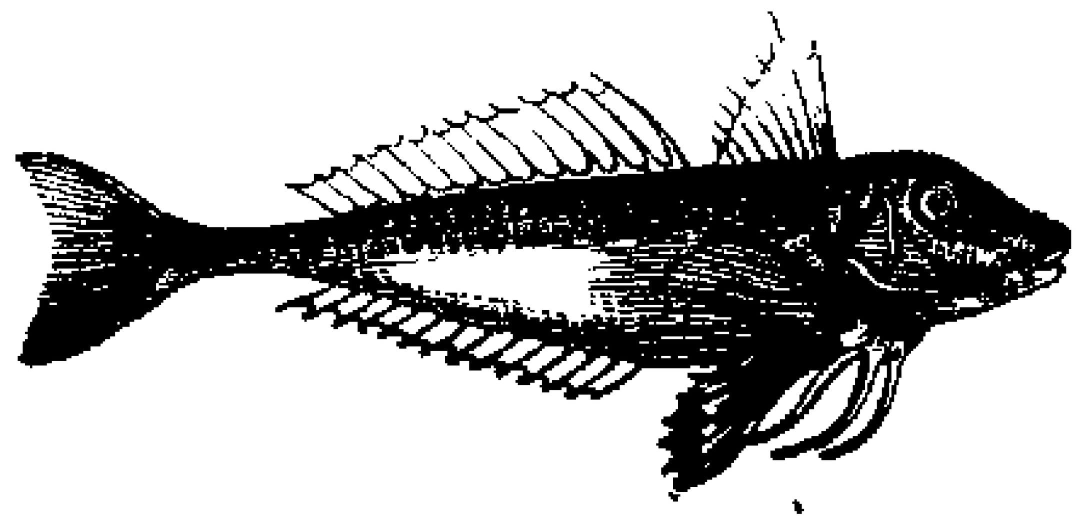


Whelk

Last and lowest of our regions of submarine existence is that of *deep-sea corals*, so named on account of the great stony zoophytes characteristic of it in the oceanic seas of Europe. Many sea-stars and sea-urchins are likewise found in this region, in the depths of which the number of peculiar creatures is few, yet sufficient to give it a marked character.

The aspect of the British submarine fauna is in general more remarkable for elegance of form and neat simplicity than for glaring or vivid hues. "The smaller kinds of sponges are not seldom brilliantly dyed, but the more conspicuous kinds are tawny or brownish. The sea-anemones are elegantly variegated with rich colours, but the majority of zoophytes are not strikingly tinted. The star-fishes, as a group, are most remarkable among the invertebrata for gorgeous painting, but our sea-urchins are sombre when compared with their relatives from warmer seas. The jelly-fish are occasionally tinged with delicate hues, and some of the smaller kinds even showily ornamented; but those which most figure in our waters are not conspicuous on account of colour, however elegant in their contours. Our marine shells, though often pretty, are not gaudy or attractive, except in rare instances. The same may be said with almost equal truth of our marine crustaceans, though, on close inspection, the elegance of device on the carapaces of many species is exceedingly admirable."

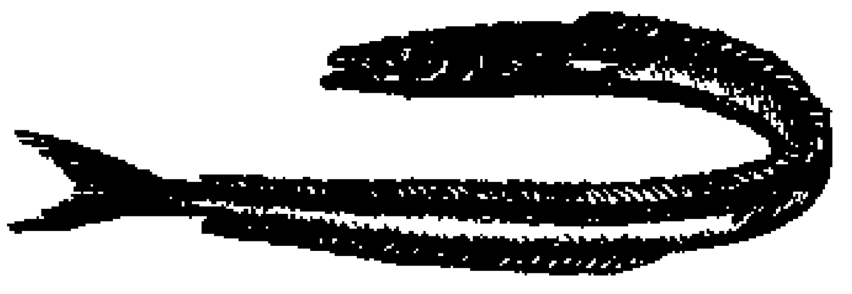
Our fishes are not distinguished by brilliancy of colour. "Their hues are quaker-like, though sufficiently lustrous for sober tinting. The cod and flounder tribes are among the most characteristic, and such of the more common fishes as belong to families of which we have but few representatives are in most instances clothed in sober grey and silver. Beauty of no mean description may, however, be displayed by these modest vestments; as, for instance, in the mackerel and the herring. Our gorgeously decorated wrasses form the chief exception to the general rule, but these belong to a family more characteristic of the southern seas. A like deficiency in the numbers of the gurnard and mackerel tribes seriously affects the aspect of our piscine fauna when compared with denizens of the Mediterranean." The sharks and rays too are comparatively deficient, although a few species, as we have seen in a former chapter, are, to the great annoyance of our fishermen, over-abundant. The sea-eels are also few, though in the common conger and



Gurnard.

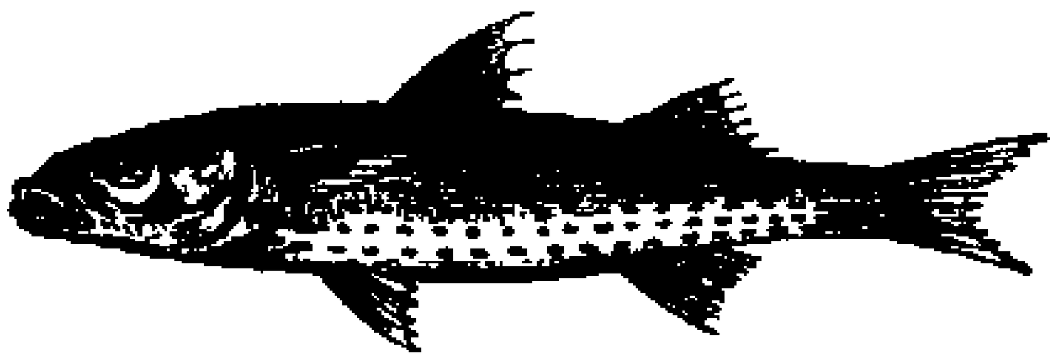
the larger sand-eel (*Ammodytes lancea*) we have two very conspicuous species.

As the surface of the British islands exhibits a transition as it were from a northern to a southern character, from the firs of Scotland to the free-growing myrtles of the Devon coast, so the inhabitants of our seas pass through a great variety of form.



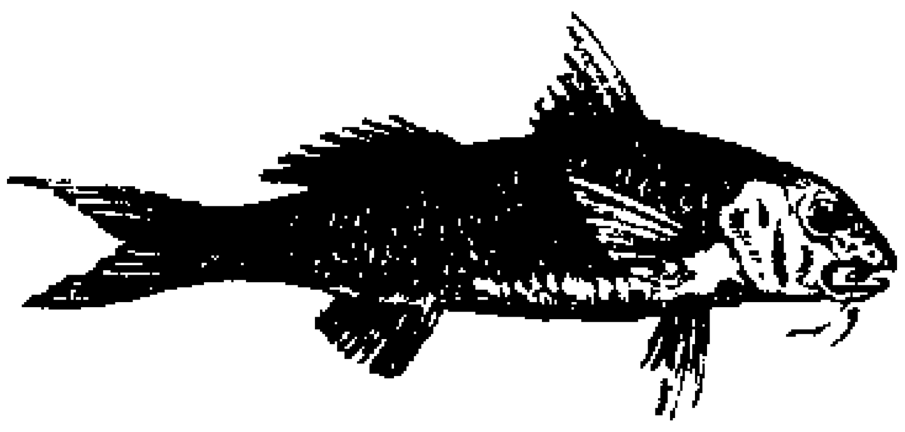
Sand-Eel.

from a northern to a southern type. While the rorqual of the Frozen Ocean not seldom strands on our northern and eastern coasts; the flying-fish of the equinoctial seas sometimes appears within view of our southern shores; and it is this peculiar position of our insular empire, fronting the colder and the warmer seas, which



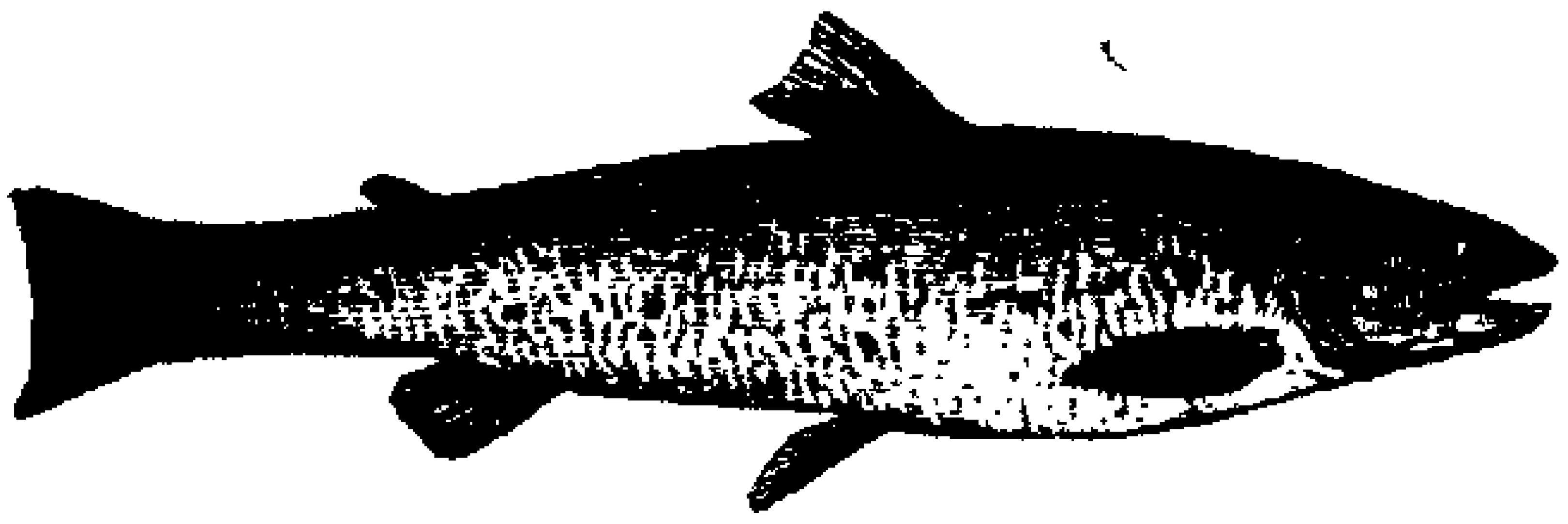
Grey Mullet.

enriches its waters with such a variety of marine life. "Several characteristic boreal forms find their southern limit within the northern half of our waters, and there some of the most striking and abundant kinds are chiefly developed in numbers, such as the cat-fish or sea-wolf (*Anarhicas lupus*), the scythe (*Merlangus carbonarius*), the ling (*Lota molva*),



Red Mullet.

the cod (*Gadus morrhua*), the lump-sucker (*Cyclopterus lumpus*), and even the herring (*Clupea harengus*). On the other hand, along the southern shores of England we find fishes becoming frequent which are distinctly of a southern



Salmon.

type, such as the grey and red mullets (*Mugil cephalus* and *Mullus barbatus*), the sea-bream, and, far more plentifully,

the John Dory (*Zeus aper*) and the pilchard (*Clupea pilchardus*)." *

Although very inferior in beauty to the tropical fishes, our finny tribes are far superior in flavour, and may well challenge the world to produce their equals for the table. The turbot, cod, whiting, herring, whitebait, mackerel, sole, and even the salmon, though it belongs rather to fluviatile history than to the chronicles of the sea, may fairly be cited to testify to the truth of this assertion; so that surely we have no reason to complain of having been but indifferently provided for in the geographical distribution of fishes, which of all marine productions are the most important to man.

The researches of Forbes led him to believe that "as we descend deeper and deeper, the denizens of the sea become fewer and fewer, indicating our approach towards a silent and desolate abyss, where life is either extinguished or exhibits but faint glimmerings to mark its lingering presence;" but subsequent deep-sea soundings, performed with improved dredging apparatuses, have led to the surprising result that the bottom of the ocean, even in its abyssal depths, far from being a dreary void, as was formerly imagined, is in reality a busy scene, absolutely teeming with life. And in this case, as in so many others, we have a fine instance of the truth of the observation that every new invention or discovery casts a new light upon some other province of human knowledge; for to the submarine telegraph we are indebted for the first certain proof of the existence of highly organised animals living at abyssal depths.

In 1860 the submarine cable between Sardinia and Bona, on the coast of Africa, having completely failed, was picked up from a depth exceeding one thousand fathoms, and found encrusted with various shells and corals. All previous observations with reference to the existence of living creatures at extreme depths had been liable to doubt from two sources. In the first place the methods of deep-sea soundings were still so imperfect that there was always a possibility, from the action of deep currents upon the sounding-line or from other causes, of a greater depth being indicated than really existed; and, secondly,

* Godwin Austen, Natural History of the European Seas, pp. 103, 104.

there was no absolute certainty that the animals entangled on the sounding instrument had actually come up from the bottom. They might have been caught on the way.

But now all doubt was removed. A submarine cable lies on the ground throughout its whole length. Before laying it, its course is carefully surveyed and the real depth accurately ascertained. Fishing it up is a delicate and difficult operation, and during its progress the depth is checked again and again. When, therefore, as in this case, the animals dragged up with a cable from depths of upwards of one thousand fathoms are found, not sticking loosely to it, but moulded upon its outer surface, or cemented to it by horny or calcareous excretions, it is evident that they must have lived and grown upon it at the bottom of the deep sea.

The subsequent dredging cruises of H.M.SS. "Porcupine" and "Lightning" in 1868, 1869, and 1870, under the scientific direction of Dr. Carpenter, Professor Wyville Thomson, and Mr. Gwyn Jeffreys, afforded additional and convincing proofs that life abounds in the abyssal regions of the ocean. During these several cruises 57 hauls of the dredge were taken at depths beyond 500 fathoms, and 16 at depths beyond 1,000 fathoms, and in all cases life was abundant. In 1869 two casts were taken in depths greater than 2,000 fathoms, and proved equally successful in bringing up specimens of deep-sea life. With the deepest cast, 2,435 fathoms, off the mouth of the Bay of Biscay, living, well-marked, and characteristic specimens of all the five invertebrate sub-kingdoms were taken. "And thus," says Professor Wyville Thomson,* "the question of the existence of abundant animal life at the bottom of the sea has been finally settled, and for all depths, for there is no reason to suppose that the depth anywhere exceeds between three and four thousand fathoms; and if there be nothing in the conditions of a depth of 2,500 fathoms to prevent the full development of a varied fauna, it is impossible to suppose that even an additional 1,000 fathoms would make any great difference."

It may be asked how the deep-sea animals bear the enormous pressure at these great depths, which seems at first sight alone

* The Depths of the Sea. London, 1873.

sufficient to put any idea of life out of the question? There was a curious popular notion that on descending deeper and deeper the sea water became gradually, under the pressure, heavier and heavier, so that at last it became more weighty than molten gold. But water is, in fact, almost incompressible; so that its density at 2,000 fathoms is scarcely appreciably increased. Any free air suspended in the water, or contained in any compressible tissue of an animal at 2,000 fathoms, would of course be reduced to a mere fraction of its bulk; but the animals subject to the pressure of the deep seas, being permeated throughout their whole organisation by incompressible fluids at the same pressure, are consequently as capable of bearing it as we do the pressure of the atmosphere. The absence of light seemed another circumstance incompatible with the existence of animal life at abyssal depths, as all plants depend upon light for their growth, and their absence apparently involves that of vegetable food, which, as we all know, forms everywhere the substratum of animal existence. We have as yet very little exact knowledge as to the distance to which the sun's light penetrates into the water of the sea. According to some recent experiments it would appear that the rays capable of affecting a delicate photographic film are very rapidly cut off, their effect being imperceptible at the depth of only a few fathoms; and though probably some portions of the sun's light possessing certain properties may penetrate to a much greater distance, it is certain that, beyond the first fifty fathoms, plants to whose existence light is essential are barely represented, and after two hundred fathoms entirely absent.

But though plant-life is thus limited to the more superficial parts of the ocean, the analysis of sea water, taken in all localities and at all depths, has shown that it everywhere contains a very appreciable and very uniform quantity of organic matter in solution and in suspension. It is thus quite intelligible that numberless protozoa—whose distinctive character is that they are capable of being supported by the absorption of organic matter through the surface of their bodies—are able to exist in the dark abysses of the sea, and in their turn afford nourishment to more highly organised animals.

After these general remarks on the creatures of the deep, I will now give a brief account of their various groups.

Over an enormous extent the abyssal ocean bottom is found covered with a sheet of almost formless beings, absolutely devoid of internal structure, and consisting merely of living and moving expansions of jelly-like matter. Whether this form of life, still more simple than the Amœba,* to which Professor Huxley has given the name of *Bathybius Haeckelii*, be continuous in one vast sheet or broken up into circumscribed individual particles, it is equally an object of wonder; and as no living thing, however slowly it may live, is ever perfectly at rest, it shows us that the bottom of the sea is, like its surface, the theatre of perpetual change.

Living among and upon this Bathybius we find a multitude of other protozoa, foraminifera and other rhizopods, radiolarians, and sponges.

Such is the countless number of the Foraminifera inhabiting the deep seas, that their remains form the chief mass of the soft oozy bottom of the ocean. In the surface layer of the deposit the shells of *Globigerina bulloides*, the prevailing species, are found fresh, whole, and living, and in the lower layers dead and gradually crumbling down by the decomposition of their organic cement and by the pressure of the layers above. Countless generations are thus piled one upon the other; and each successive stratum, weighing upon those of older date, is laying the foundation of future rocks, which subsequent revolutions may perhaps heave out of the deep and raise in towering pinnacles to the skies.

Sponges † of wonderful beauty and lustre appear to extend in endless variety over the whole of the bottom of the sea. Some (*Holtenia Carpenteri*) anchor in the ooze by means of a perfect maze of delicate glassy filaments, like fine white hair, spreading out in all directions through the sea's fluid mud; while others (*Hyalonema*) send right down a coiled whisp of strong spicules, each as thick as a knitting-needle, which open out into a brush as the bed gets firmer, and fix the sponge in its place somewhat on the principle of a screw-pile. "A very singular sponge, from deep water off the Loffoden Islands, spreads into a thin circular cake, and adds to its surface by sending out a flat border of silky spicules, like a fringe of white

* See Chapter VIII., p. 380. † Ibid. pp. 385–389.

floss silk round a little yellow mat; and the lovely Euplectella, whose beauty is imbedded up to its fretted lid in the grey mud of the seas of the Philippines, is supported by a frill of spicules standing up round it like Queen Elizabeth's ruff."*

The stalked sea-stars, which, as the fossil pentacrinites and encrinites testify, abounded in the past periods of the earth's history, were, until now, supposed to be on the verge of extinction; but when we consider that the first few scrapes of the dredge at great depths have brought new species to light, we are entitled to believe that they constitute an important element in the abyssal fauna, and probably pave large tracts of the sea-bottom with a carpet of animated flowers. Freely-moving sea-stars and sea-urchins have likewise been hauled up in great numbers from abyssal depths; crustaceans have not been found wanting, and the captured shell-fish have shown that the deep-sea molluscs are by no means deficient in colour, though as a rule they are paler than those from shallow water.

Dacrydium vitreum, dredged from 2,435 fathoms, a curious little mytiloïd shell-fish, which makes and inhabits a delicate flask-shaped tube of foraminifera and other foreign bodies cemented together by organic matter and lined by a delicate membrane, is of a fine reddish-brown colour dashed with green, and the animals of one or two species of Lima from extreme depths are of the usual vivid orange scarlet.

Some of the abyssal molluscs have even been found provided with organs of sight. A new species of Pleurotoma, from 2,090 fathoms, had a pair of well-developed eyes on short foot-stalks, and a Fusus from 1,207 fathoms was similarly provided. The presence of organs of sight at these great depths leaves little room to doubt that light must reach even these abysses from some source, and as from many considerations it can scarcely be sunlight, Professor Wyville Thomson throws out the suggestion "that the whole of the light beyond a certain depth may be due to phosphorescence, which is certainly very general, particularly among the larvæ and young of deep-sea animals."

Thus many of the creatures dredged in the Northern Atlantic, off the west coast of Ireland,† in depths varying from 557 to 584

* The Depths of the Sea, p. 73.

† Ibid., Chapter III. Cruise of the "Porcupine," pp. 98–149.

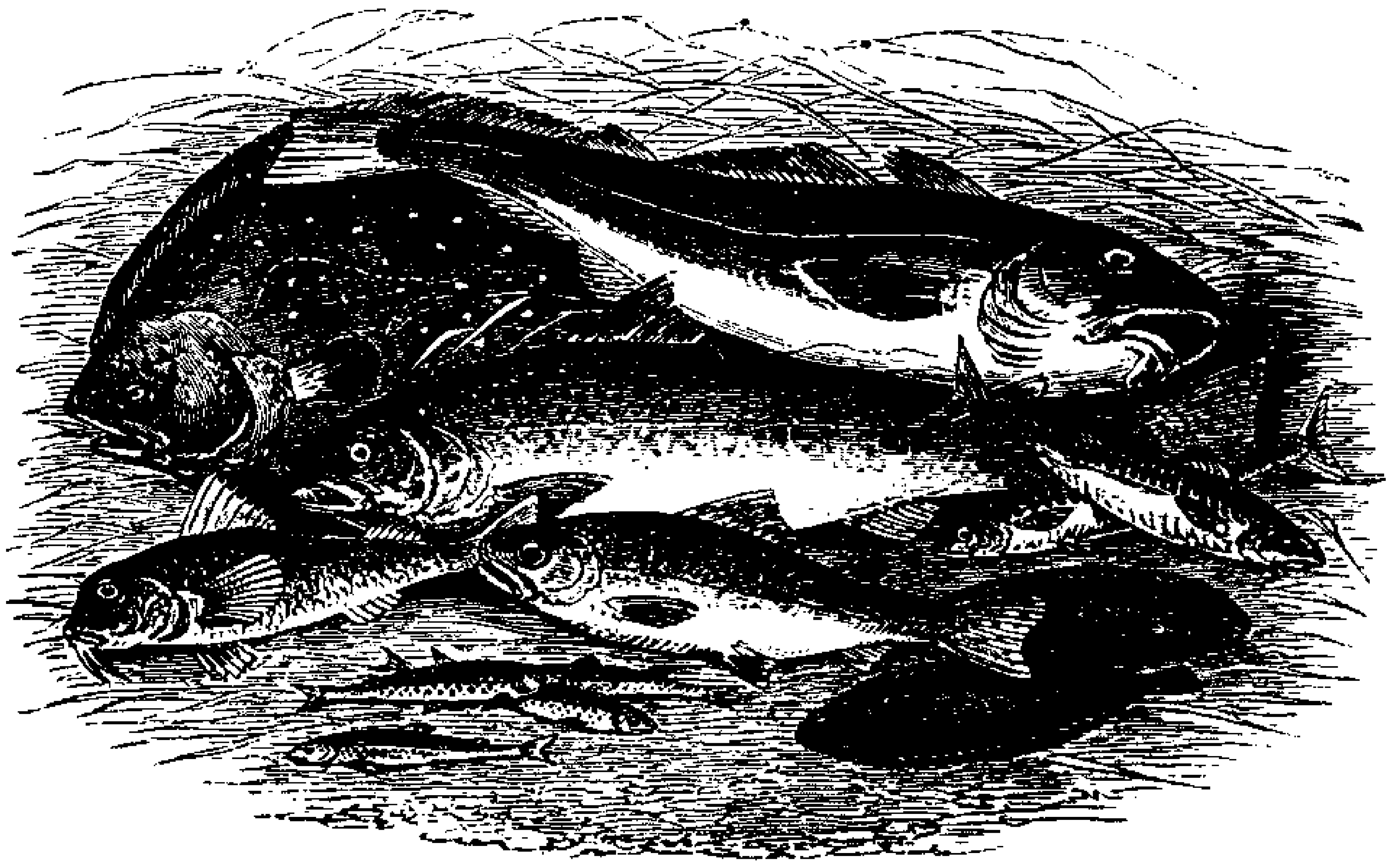
fathoms, were most brilliantly phosphorescent. In some places nearly everything brought up seemed to emit light, and the mud itself was perfectly full of luminous specks. The alcyonarians, the brittle-stars, and some annelids were the most brilliant. The Pennatidæ, the Virgulariæ, and the Gorgoniæ shone with a lambent white light, so bright that it showed quite distinctly the hour on a watch, while the light from *Ophiacantha spinulosa* was of a brilliant green, coruscating from the centre of the disk, now along one arm, now along another, and sometimes vividly illuminating the whole outline of the star-fish. While the Ophiacantha shines like a star of the most vivid uranium green, the sea-pen (*Pavonaria quadrangularis*) is resplendent with a pale lilac phosphorescence like the flame of cyanogen gas, not scintillating like the green light of Ophiacantha, but almost constant, sometimes flashing out at one point more vividly, and then dying gradually into comparative dimness, but still sufficiently bright to make every portion of the polyp visible.

Such numbers of the Pavonaria were brought up at one haul of the dredge in the Sound of Skye, that the "Porcupine" had evidently passed over a forest of them. While the darkness of winter frowns over the surface of the Northern Atlantic, the animated shrubs at its bottom are thus glowing with light, and a kind of magical day prevails in depths which were supposed to be shrouded with perpetual night. But it might have been better for many of the luminous denizens of the abyss if a more obscure existence had been their lot; for in a sea swarming with predaceous crustaceans with great bright eyes phosphorescence must surely be a fatal gift.

Off the coast of Portugal there is a great fishery of sharks (*Centroscymnus Cœlolepis*), carried on at a depth of 500 fathoms. If an animal so highly organised as a shark can thus bear without inconvenience the enormous pressure of more than half a ton on the square inch existing at that depth, it is a sufficient proof that the pressure is applied under circumstances which prevent its affecting it to its prejudice, and there seems to be no reason why it should not tolerate equally well a pressure of one or two tons, or why many other fishes—though

the dredge, in consequence of their facility of locomotion, will hardly ever be able to bring them to light—should not abound in the still waters of the abyssal deep.

The "Challenger" Exploring Expedition will no doubt reveal to us still many an unknown wonder of those interesting regions, and make us acquainted with a world of new animals which even the profundity of the ocean vainly strives to hide from the curiosity of man.



CHAP. XXI.

THE PHOSPHORESCENCE OF THE SEA.

Its Causes. — Noctiluca miliaris. — Phosphorescent Annelides and Beroes. — Intense Phosphorescence of the Pyrosoma atlantica.—Luminous Pholades.—The luminous Shark.—Phosphorescent Algæ.—Citations from Byron, Coleridge, and Crabbe.

He who still lingers on the shore after the shades of evening have descended, not seldom enjoys a most magnificent spectacle; for lucid flashes burst from the bosom of the waters, as if the sea were anxious to restore to the darkened heavens the light it had received from them during the day. On approaching the margin of the rising flood to examine more closely the sparkling of the breaking wave, the spreading waters seem to cover the beach with a sheet of fire. Each footstep over the moist sands elicits luminous star-like points, and a splash in the water resembles the awakening of slumbering flames.

The same wonderful and beauteous aspect frequently gladdens the eye of the navigator who ploughs his way through the wide deserts of ocean, particularly if his course leads him through the tropical seas.

"When a vessel," says Humboldt, "driven along by a fresh wind, divides the foaming waters, one never wearies of the lovely spectacle their agitation affords; for, whenever a wave makes the ship incline sideways, bluish or reddish flames seem to shoot upwards from the keel. Beautiful beyond description is the sight of a troop of dolphins gambolling in the phosphorescent sea. Every furrow they draw through the waters is marked by streaks of intense light. In the Gulf of Cariaco, between Cumana and the peninsula of Maniquarez, this scene has often delighted me for hours."

But even in the colder oceanic regions the brilliant phenomenon appears from time to time in its full glory. During a dark and stormy September night, on the way from the Sea-

lion island, Saint George, to Unalaschka, Chamisso admired as beautiful a phosphorescence of the ocean as he had ever witnessed in the tropical seas. Sparks of light, remaining attached to the sails that had been wetted by the spray, continued to glow in another element. Near the south point of Kamtschatka, at a water-temperature hardly above freezing point, Ermann saw the sea no less luminous than during a seven months' sojourn in the tropical ocean. This distinguished traveller positively denies that warmth decidedly favours the luminosity of the sea.

At Cape Colborn, one of the desolate promontories of the deso late Victoria Land, the phosphoric gleaming of the waves on the 6th September, when darkness closed in, was so intense that Simpson assures us he had seldom seen anything more brilliant. The boats seemed to cleave a flood of molten silver, and the spray dashed from their bows, before the fresh breeze, fell back in glittering showers into the deep.

Mr. Charles Darwin paints in vivid colours the magnificent spectacle presented by the sea, while sailing in the latitudes of Cape Horn on a very dark night.

There was a fresh breeze, and every part of the surface, which during the day is seen as foam, now glowed with a pale light. The vessel drove before her bows two billows of liquid phosphorus, and in her wake she was followed by a milky train. As far as the eye reached, the crest of every wave was bright, and the sky above the horizon, from the reflected glare of these livid flames, was not so utterly obscure as over the rest of the heavens.

While "La Venus" was at anchor before Simon's Town, the breaking of the waves produced so strong a light that the room in which the naturalists of the expedition were seated was illumined as by sudden flashes of lightning. Although more than fifty paces from the beach where the phenomenon took place, they tried to read by this wondrous oceanic light, but the successive glimpses were of too short duration to gratify their wishes.

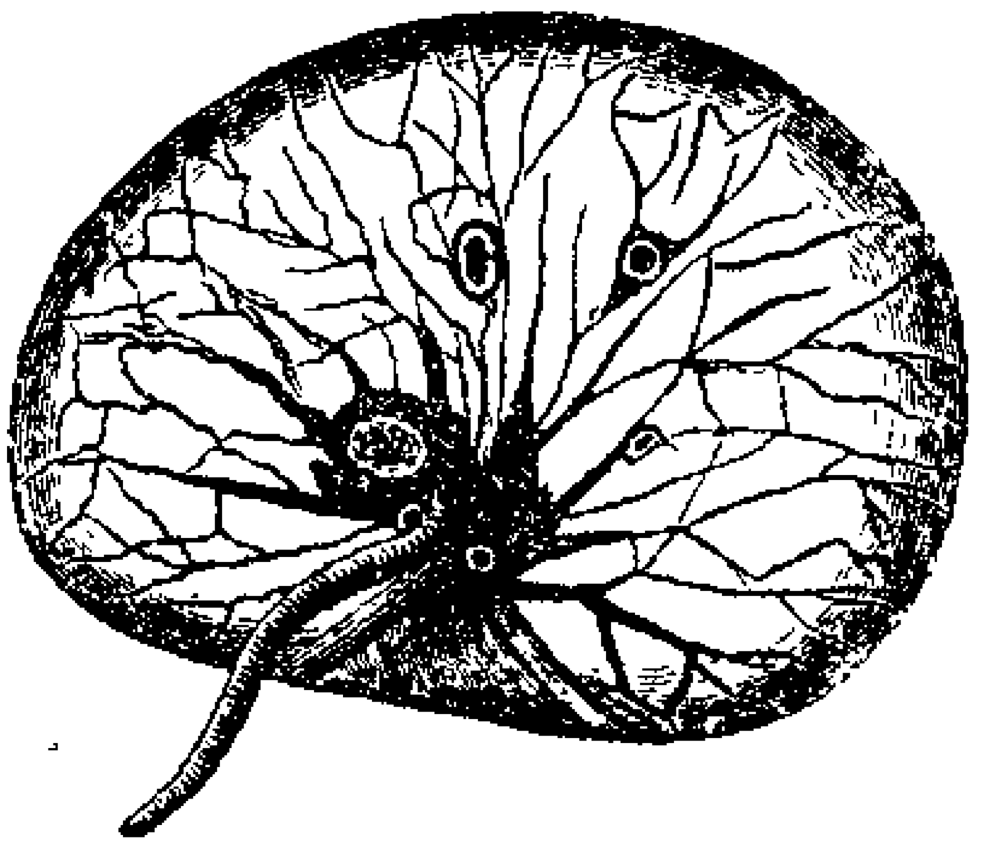
Thus we see the same nocturnal splendour which shines forth in the tropical seas, and gleams along our shores, burst forth from the arctic waters, and from the waves that bathe the southern promontories of the old and the new worlds.

But what is the cause of the beautiful phenomenon so widely

spread over the face of ocean? How comes it that at certain times flames issue from the bosom of an element generally so hostile to their appearance?

Without troubling the reader with the groundless surmises of ancient naturalists, or repeating the useless tales of the past, I shall at once place myself with him on the stage of our actual knowledge of this interesting and mysterious subject. It is now no longer a matter of doubt that many of the inferior marine animals possess the faculty of secreting a luminous matter, and thus adding their mite to the grand phenomenon. When we consider their countless multitudes, we shall no longer wonder at such magnificent effects being produced by creatures individually so insignificant.

In our seas it is chiefly a minute gelatinous animal, the *Noctiluca miliaris*, most probably an aberrant member of the infusorial group, which, as it were, repeats the splendid spectacle of the starry heavens on the surface of the ocean. In form it is nearly globular, presenting on one side a groove, from the anterior extremity of which issues a peculiar curved stalk or appendage, marked by transverse lines, which might seem to be made use of as an organ of locomotion. Near the base of this tentacle is placed the mouth, which passes into a dilatable digestive cavity, leading, according to Mr. Huxley, to a distinct anal orifice. From the rather firm external coat proceed thread-like prolongations through the softer mass of the body, so as to divide it into irregular chambers. This little creature, which is just large enough to be discerned by the naked eye when the water in which it may be swimming is contained in a glass jar exposed to the light, seems to feed on diatoms, as their loricæ may frequently be detected in its interior. It multiplies by spontaneous fission, and the rapidity of this process may be inferred from the immensity of its numbers. A single bucket of luminous sea-water will often contain thousands, while for miles and miles every wave breaking on the shore expands in a sheet of living flame. It was first described by Forster in the Pacific Ocean; it occurs on all the shores of the Atlantic, and the



Noctiluca miliaris.
(Highly magnified.)

Polar Seas are illuminated by its fairy light. "The nature of its luminosity," says Dr. Carpenter, "is found by microscopic examination to be very peculiar; for what appears to the eye to be a uniform glow is resolvable under a sufficient magnifying power into a multitude of evanescent scintillations, and these are given forth with increased intensity whenever the body of the animal receives any mechanical shock."

The power of emitting a phosphorescent light is widely diffused both among the free-swimming and the sessile Cœlenterata. Many of the Physophoridæ are remarkable for its manifestation, and a great number of the jelly-fishes are luminous. Our own *Thaumantias lucifera*, a small and by no means rare medusid, displays the phenomenon in a very beautiful manner, for, when irritated by contact of fresh water, it marks its position by a vivid circlet of tiny stars, each shining from the base of a tentacle. A remarkable greenish light, like that of burning silver, may also be seen to glow from many of our Sertularians, becoming much brighter under various modes of excitation.

Among the Ctenophora the large *Cestum Veneris* of the Mediterranean is specially distinguished for its luminosity, and while moving beneath the surface of the water gleams at night like a brilliant band of flame.

The Sea-pens are eminently phosphorescent, shining at night with a golden-green light of a most wonderful softness. When touched, every branchlet above the shock emits a phosphoric glow, while all the polyps beneath remain in darkness. When thrown into fresh water or alcohol, they scatter sparks about in all directions, a most beautiful sight; dying, as it were, in a halo of glory.

But of all the marine animals the Pyrosomas, doing full justice to their name (fire-bodies) seem to emit the most vivid coruscations. Bibra relates in his "Travels to Chili" that he once caught half a dozen of these remarkable light-bearers, by whose phosphorescence he could distinctly read their own description in a naturalist's vade-mecum. Although completely dark when at rest the slightest touch sufficed to elicit their clear blue-green light. During a voyage to India, Mr. Bennett had occasion to admire the magnificent spectacle afforded by whole shoals of Pyrosomas. The ship, proceeding at a rapid rate, continued during an entire night to pass through distinct but extensive

fields of these molluscs, floating and glowing as they floated on all sides of her course. Enveloped in a flame of bright phosphorescent light, and gleaming with a greenish lustre, the Pyrosomes, in vast sheets, upwards of a mile in breadth, and stretching out till lost in the distance, presented a sight, the glory of which may be easily imagined. The vessel, as it cleaved the gleaming mass, threw up strong flashes of light, as if ploughing through liquid fire, which illuminated the hull, the sails, and the ropes, with a strange unearthly radiance.

In his memoir on the Pyrosoma, M. Péron describes with lively colours the circumstances under which he first made its discovery, during a dark and stormy night, in the tropical Atlantic. "The sky," says this distinguished naturalist, "was on all sides loaded with heavy clouds; all around the obscurity was profound; the wind blew violently, and the ship cut her way with rapidity. Suddenly we discovered at some distance a great phosphorescent band stretched across the waves, and occupying an immense tract in advance of the ship. Heightened by the surrounding circumstances, the effect of this spectacle was romantic, imposing, sublime, rivetting the attention of all on board. Soon we reached the illuminated tract, and perceived that the prodigious brightness was certainly and only attributable to the presence of an innumerable multitude of largish animals floating with the waves. From their swimming at different depths they took apparently different forms: those at the greatest depth were very indefinite, presenting much the appearance of great masses of fire, or rather of enormous red-hot cannon balls; whilst those more distinctly seen near the surface perfectly resembled incandescent cylinders of iron.

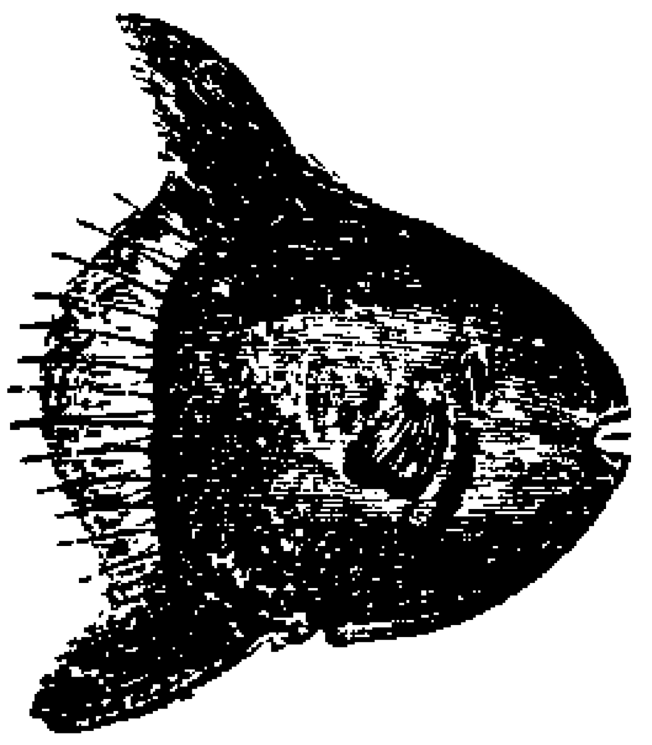
"Taken from the water, these animals entirely resembled each other in form, colour, substance, and the property of phosphorescence, differing only in their sizes, which varied from three to seven inches. The large, longish tubercles with which the exterior of the Pyrosomes was bristled were of a firmer substance, and more transparent than the rest of the body, and were brilliant and polished like diamonds. These were the principal scene of phosphorescence. Between these large tubercles, smaller ones, shorter and more obtuse, could be distinguished; these also were phosphorescent. Lastly, in the interior of the substance of the animal, could be seen, by the

aid of the transparency, a number of little, elongated, narrow bodies (viscera), which also participated in a high degree in the possession of the phosphoric light."

In the Pholades or Lithodomes, that bore their dwellings in the hard stone, as other shell-fish do in the loose sands, the whole mass of the body is permeated with light. Pliny gives us a short but animated description of the phenomenon in the edible date-shell of the Mediterranean (*Pholas dactylus*):—

"It is in the nature of the pholades to shine in the darkness with their own light, which is the more intense as the animal is more juicy. While eating them, they shine in the mouth and on the hands, nay, even the drops falling from them upon the ground continue to emit light, a sure proof that the luminosity we admire in them is associated with their juice." Milne-Edwards found this observation perfectly correct, for wishing to place some living pholades in alcohol, he saw a luminous matter exude from their bodies, which on account of its weight sank in the liquid, covering the bottom of the vessel, and there forming a deposit as shining as when it was in contact with the air.

Several kinds of fishes likewise possess the luminous faculty. The sun-fish, that strange deformity, emits a phosphoric gleam; and a species of Gurnard (*Trigla lucerna* is said to sparkle in the night, so as to form fiery streams through the water.



Short Sun-Fish.

With regard to the luminosity of the larger marine animals, Ermann, however, remarks that he so often saw small luminous crustacea in the abdominal cavity of the transparent *Salpa pinnata*, that it may well be asked whether the phosphorescence of the larger creatures is not in reality owing to that of their smaller companions.

According to Mr. Bennett, "Whaling Voyage round the Globe," a species of shark first discovered by himself is distinguished by an uncommonly strong emission of light. When the specimen, taken at night, was removed into a dark apartment, it afforded a very interesting spectacle. The entire inferior surface of the body and head emitted a vivid and greenish phosphorescent gleam, imparting to the creature by its own light a truly ghastly and terrific appearance. The luminous effect was constant, and

not perceptibly increased by agitation or friction. When the shark expired, (which was not until it had been out of the water more than three hours,) the luminous appearance faded entirely from the abdomen, and more gradually from other parts; lingering longest around the jaws and on the fins.

The only part of the under surface of the animal which was free from luminosity was the black collar round the throat; and while the inferior surface of the pectoral, anal, and caudal fins shone with splendour, their superior surface (including the upper lobe of the tail fin) was in darkness, as were also the dorsal fins, and the back and summit of the head.

Mr. Bennett is inclined to believe that the luminous power of this shark resides in a peculiar secretion from the skin. It was his first impression that the fish had accidentally contracted some phosphorescent matter from the sea, or from the net in which it was captured; but the most rigid investigation did not confirm this suspicion, while the uniformity with which the luminous gleam occupied certain portions of the body and fins, its permanence during life, and decline and cessation upon the approach and occurrence of death, did not leave a doubt in his mind but that it was a vital principle essential to the economy of the animal. The small size of the fins would appear to denote that this fish is not active in swimming; and, since it is highly predaceous and evidently of nocturnal habits, we may perhaps indulge in the hypothesis, that the phosphorescent power it possesses is of use to attract its prey, upon the same principle as the Polynesian islanders and others employ torches in night-fishing.

Some of the lower sea-plants also appear to be luminous. Thus, over a space of more than 600 miles (between lat. 8° N. and 2° S.), Meyen saw the ocean covered with phosphorescent Oscillatoria, grouped together into small balls or globules, from the size of a poppy-seed to that of a lentil.

But if the luminosity of the ocean generally proceeds from living creatures, it sometimes also arises from putrefying organic fibres and membranes, resulting from the decomposition of those living light-bearers. "Sometimes," says Humboldt, "even a high magnifying power is unable to discover any animals in the phosphorescent water, and yet light gleams forth wherever a wave strikes against a hard body and dissolves in foam. The

cause of this phenomenon lies then most likely in the putrefying fibres of dead mollusks, which are mixed with the waters in countless numbers."

Summing up the foregoing in a few words, it is thus an indisputable fact, that the phosphorescence of the sea is by no means an electrical or magnetic property of the water, but exclusively bound to organic matter, living or dead. But although thus much has been ascertained, we have as yet only advanced one step towards the unravelling of the mystery, and its proximate cause remains an open question. Unfortunately, science is still unable to give a positive answer, and we are obliged to be contented with a more or less plausible hypothesis. When we consider that the phosphorescence most commonly resides only in the outward mucous covering of the body, in which a number of particles cast off by the skin are continually undergoing decomposition, the phenomenon seems to be a simple chemical process, during which more or less phosphorus may be disengaged, which by agitation or friction gives rise to the emission of light. It is more difficult to explain those cases in which the entire mass of the body is luminous (as in Pholas), or the muscular substance (as in some Annelides), or the vibratory cilia (as in the Beroës); and here we do better to confess our entire ignorance, than to resort to the hypothesis of electrical discharges, extremely improbable in an element which is so excellent an electrical conductor, and particularly when we consider that no emission of light takes place in the few and powerful electrical fishes we are acquainted with.

We know as little of what utility marine phosphorescence may be. Why do the countless myriads of Mammariæ gleam and sparkle along our coasts? Is it to signify their presence to other animals, and direct them to the spot where they may find abundance of food? So much is certain, that so grand and widespread a phenomenon must necessarily serve some end equally grand and important.

As the phosphorescence of the sea is owing to living creatures, it must naturally show itself in its greatest brilliancy when the ocean is at rest; for during the daytime we find the surface of the waters most peopled with various animals when only a slight zephyr glides over the sea. In stormy weather, the fragile or gelatinous world of the lower marine creatures generally seeks a

greater depth, until the elementary strife has ceased, when it again loves to sport in the warmer or more cheerful superficial waters.

In the tropical zone, Humboldt saw the sea most brilliantly luminous before a storm, when the air was sultry, and the sky covered with clouds. In the North Sea we observe the phenomenon most commonly during fine tranquil autumnal nights; but it may be seen at every season of the year, even when the cold is most intense. Its appearance is, however, extremely capricious; for, under seemingly unaltered circumstances, the sea may one night be very luminous, and the next quite dark. Often months, or even years, pass by without witnessing it in full perfection. Does this result from a peculiar state of the atmosphere, or do the little animals love to migrate from one part of the coast to another?

It is remarkable that the ancients should have taken so little notice of oceanic phosphorescence. The "Periplus" of Hanno contains perhaps the only passage in which the phenomenon is described. To the south of Cerne the Carthaginian navigator saw the sea burn, as it were, with streams of fire. Pliny, in whom the miracle (*miraculum*, as he calls it) of the date-shell excited so lively an admiration, and who must often have seen the sea gleam with phosphoric light, as the passage proves where he mentions in a few dry words the luminous gurnard (*lucerna*) stretching out a fiery tongue, has no exclamation of delight for one of the most beautiful sights in nature. Homer also, who has given us so many charming descriptions of the sea in its ever-changing aspects, and who so often leads us with long-suffering Ulysses through the nocturnal floods, never once makes them blaze or sparkle in his immortal hexameters.

Even modern poets mention the phenomenon but rarely. Camoens himself, whom Humboldt, on account of his beautiful oceanic descriptions, calls, above all others, the "poet of the sea," forgets to sing it in his Lusiad. Byron in his "Corsair" has a few lines on the subject:

> "Flash'd the dipt oars, and, sparkling with the stroke,
> Around the waves phosphoric brightness broke;"

but contents himself, as we see, with coldly mentioning a phenomenon so worthy of all a poet's enthusiasm. In Coleridge's

wondrous ballad of "The ancient Mariner" we find a warmer description:

"Beyond the shadow of the ship
I watch'd the water-snakes:
They moved in tracks of shining white,
And, when they rear'd, the elfish light
Fell off in hoary flakes.

"Within the shadow of the ship
I watch'd their rich attire—
Blue, glossy green, and velvet black:
They coiled and swam, and every track
Was a flash of golden fire."

These indeed are lines whose brilliancy emulates the splendour of the phenomenon they depict, but even they are hardly more beautiful than Crabbe's admirable description:

"And now your view upon the ocean turn,
And there the splendour of the waves discern;
Cast but a stone, or strike them with an oar,
And you shall flames within the deep explore;
Or scoop the stream phosphoric as you stand,
And the cold flames shall flash along your hand;
When, lost in wonder, you shall walk and gaze
On weeds that sparkle, and on waves that blaze."

Or than the graphic numbers of Sir Walter Scott:

"Awak'd before the rushing prow,
The mimic fires of ocean glow,
Those lightnings of the wave;
Wild sparkles crest the broken tides.
And flashing round, the vessel's sides
With elfish lustre lave;
While, far behind, their livid light
To the dark billows of the night
A blooming splendour gave."

PART III.

THE

PROGRESS OF MARITIME DISCOVERY.

CHAP. XXIII.

Maritime Discoveries of the Phœnicians. — Expedition of Hanno. — Circumnavigation of Africa under the Pharaoh Necho. — Colæus of Samos. — Pytheas of Massilia. — Expedition of Nearchus. — Circumnavigation of Hindostan under the Ptolemies. — Voyages of Discovery of the Romans. — Consequences of the Fall of the Roman Empire. — Amalfi. — Pisa. — Venice. — Genoa. — Resumption of Maritime Intercourse between the Mediterranean and the Atlantic. — Discovery of the Mariner's Compass. — Marco Polo.

Among the nations of antiquity, navigation, as may well be supposed, was in a very rude and imperfect state. Unacquainted with the mariner's compass, which during the darkest and most tempestuous nights safely leads the modern seaman over the pathless ocean, the sparkling constellations of a serene sky, or the position of the sun, were the only guides of the ancient navigator. He therefore rarely ventured to lose sight of land, but cautiously steering his little bark along the shore, was subject to all the delays and dangers of coast navigation. Even under the mild sky and in the calm waters of the Mediterranean, it was only during the summer months that he dared to leave the port; to brave the fury of the wintry winds was a boldness he never could have thought of. Under such adverse circumstances, it is surely far less astonishing that the geographical knowledge of the ancients was so extremely limited when compared with ours, than that with means so scanty they yet should have known so much of the boundaries of ocean.

But the spirit of commercial enterprise triumphs over every difficulty. Stimulated by the love of gain, and the hope of discovering new sources of wealth, the Phœnicians, the first great maritime nation mentioned in history, were continually enlarging the limits of the known earth, until the fatal moment when the sword of the conqueror destroyed their cities, and extinguished their power for ever.

The first periods of Phœnician greatness are veiled in the mysterious darkness of an unknown past, yet so much is certain,

that their date must have been very remote; as, according to the accounts which Herodotus received from the priests, the foundation of Tyre took place thirty centuries before the Christian era.

Long before the expedition of the Argonauts, the Phœnicians had already founded colonies on the Bithynian coast of the Black Sea (Pronectus, Bithynium); and that at a very early time they must have steered through the Straits of Gades into the Atlantic is proved by the fact, that, as far back as the eleventh century before Christ, they founded the towns of Gades and Tartessus on the western coast of Southern Spain. Penetrating farther and farther to the north, they discovered Britain, where they established their chief station on the Scilly Isles, at present so insignificant and obscure, and even visited the barbarous shores of the Baltic in quest of the costly amber. They planted their colonies along the north-west coast of Africa, even beyond the tropic; and, 2000 years before Vasco de Gama, Phœnician mariners are said to have circumnavigated that continent, for Herodotus relates that a Tyrian fleet, fitted out by Necho II., Pharaoh of Egypt (611—595 B.C.), sailed from a port in the Red Sea, doubled the southern promontory of Africa, and, after a voyage of three years, returned through the Straits of Gades to the mouth of the Nile.

Less wonderful, but resting on better historical proof, is the celebrated voyage of discovery to the south which Hanno performed by command of the senate of Carthage, the greatest of all Phœnician colonies, eclipsing even the fame of Tyre itself. Sailing from Cerne, the principal Phœnician settlement on the western coast of Africa, and which was probably situated on the present island of Arguin, he reached, after a navigation of seventeen days, a promontory which he called the West Horn (probably Cape Palmas), and then advanced to another cape, to which he gave the name of South Horn, and which is manifestly Cape de Tres Puntas, only 5° north of the line. During daytime the deepest silence reigned along the newly discovered coast, but after sunset countless fires were seen burning along the banks of the rivers, and the air resounded with music and song, the black natives spending, as they still do now, the hours of the cool night in festive joy. Most likely the Canary Islands were also known to the Phœnicians, as the summit of the Peak of Teneriffe is visible from the heights of Cape Bojador.

The progress of the great mariners of old in the Indian Ocean was no less remarkable than the extension of their Atlantic discoveries. Far beyond Bab-el-Mandeb their fleets sailed to Ophir or Supara, and returned with rich cargoes of gold, silver, sandal-wood, jewels, ivory, apes, and peacocks, to the ports of Elath and Ezion-Geber at the head of the Red Sea. These costly productions of the south were then transported across the Isthmus of Suez to Rhinocolura, the nearest port on the Mediterranean, and thence to Tyre, which ultimately distributed them over the whole of the known world.

The true position of Ophir is an enigma which no learned Œdipus will ever solve. While some authorities place it on the east coast of Africa, others fix its situation somewhere on the west coast of the Indian peninsula; and Humboldt is even of opinion that the name had only a general signification, and that a voyage to Ophir meant nothing more than a commercial expedition to any part of the Indian Ocean, just as at present we speak of a voyage to the Levant or the West Indies.

But whatever Ophir may have been, it is certain that the Phœnicians carried on a considerable trade with the lands and nations beyond the Gates of the Red Sea. Their trade in the direction of the Persian Gulf was no less extensive. Through the Syrian desert, where Palmyra, their chief station or emporium, proudly rose above the surrounding sands, their caravans slowly wandered to the banks of the Tigris and Euphrates, to provide Nineveh and Babylon with the costly merchandise of Sidon and Tyre. Following the course of the great Mesopotamian streams, they reached the shores of the Persian Gulf, where they owned the ports of Tylos and Aradus and the rich pearl islands of Bahrein, and, having loaded their empty camels with the produce of Iran and Arabia, returned by the same way to the shores of the Mediterranean. How far their ships may have ventured beyond the mouth of the Persian Gulf is unknown, but the researches of the learned orientalists, Gesenius, Benfey, and Lassen, render it extremely probable, that, taking advantage of the regularly changing monsoons, they sailed through the Straits of Ormus to the coast of Malabar.

The progress of the Phœnician race in the technical arts, as well as in the astronomical and mathematical sciences so highly important for the improvement of their navigation, was no less remarkable for the age in which they lived, than the vast

extension of a commercial intercourse which reached from Britain to the Indus, and from the Black Sea to the Senegal. They wove the finest linen, and knew how to dye it with the most splendid purple. They were unsurpassed in the workmanship of metals, and possessed the secret of manufacturing white and coloured glass, which their caravans and ships exchanged for the produce of the north and of the south. By the invention of the alphabet, which with many other useful sciences and arts, they communicated to the Greeks and other nations with whom they traded, they no less contributed to the progress of mankind than by the humanising influence of commerce.

Thus when we consider the services which these merchant-princes of antiquity rendered to their contemporaries, wherever their flag was seen or their caravans appeared, the annihilation of the maritime power of Tyre by Alexander (332 B.C.), and the destruction of Carthage by the Romans (146 B.C.), must strike us as events calamitous to the whole human race. Had the Carthaginians, so distinguished by their commercial spirit and ardour for discovery, triumphed over the semi-barbarous Romans, who, then at least, had not yet learned to imitate the arts of plundered Greece, there is every probability that some Punic Columbus would have discovered America at least a thousand years sooner, and the world at this day be in possession of many secrets still unknown, and destined to contribute to the comforts or enjoyments of our descendants.

In the times of Homer, when the Indian Ocean and the Atlantic had long been known to the Phœnicians, the geographical knowledge of the Greeks was still circumscribed by the narrow limits of the Eastern Mediterranean and part of the Euxine, and many a century elapsed ere their ships ventured beyond the Straits of Gades. Colæus of Samos (639 B.C.) is said to have been the first seafarer of Hellenic race who sailed forth into the Atlantic, compelled by adverse winds, and was able on his return from his involuntary voyage to tell his astonished countrymen of the wondrous rising and falling of the oceanic tides. It was seventy years later before the Phoceans of Massilia, the present Marseilles, ventured to follow the path he had traced out, and to visit the Atlantic port of Tartessus.

The town of Massilia had the additional honour of reckoning among her sons the great traveller Pytheas, the Marco Polo of

antiquity. This far-wandering philosopher, who lived about 330 years before Christ, had visited all the coasts of Europe, from the mouths of the Tanais or Don to the shores of Ultima Thule, which, according to Leopold von Buch, was not Iceland, nor Feroe, nor Orcadia, but the Norwegian coast. His narrative first made the Greeks acquainted with North-western Europe, and remained for a long time their only geographical guide to those hyperborean lands.

While the horizon of the Greeks was thus considerably expanding towards the regions of the setting sun, the conquests of Alexander opened to them a new world in the distant Orient. Greek navigators now for the first time unfurled their sails on the Indian Ocean. The Macedonian, desirous not only of subduing Asia but of firmly attaching it to the nations of the Mediterranean by the bonds of mutual interest, and hoping by this means to consolidate his vast conquests, sent a fleet under the command of Nearchus, from the mouths of the Indus to the head of the Persian Gulf, to establish if possible a new road for a regular commercial intercourse between India and Mesopotamia. The performance of this voyage was reckoned by the conqueror one of the most glorious events of his reign, but it may serve as a proof of the slowness of ancient navigation, that Nearchus took ten months to perform a journey which one of our steamers might easily accomplish in five days.

After the disruption of the Macedonian empire, the circle of the Greek discoveries in the Indian Ocean was widened by the enterprising spirit of the Seleucidæ and Ptolemies. Seleucus Nicator is said to have penetrated to the mouths of the Ganges, and the fleets of the Egyptian kings sailed round the peninsula of Hindostan and discovered the coasts of Taprobane or Ceylon, the spicy odours of whose cinnamon-groves are said to be wafted far out to sea, so that —

> "for many a league,
> Pleased with the grateful scent, old Ocean smiles."

But now came the time when earth-ruling Rome called the whole civilised world her own, and her victorious eagles expanded their triumphant wings from the Red Sea to the coasts of the Northern Ocean. What discoveries might not have been expected from such a power, if the Romans had possessed but one

tithe of the maritime spirit of conquered Carthage? But even this military empire contributed something to the enlargement of maritime knowledge. Under the reign of Augustus a Roman fleet sailed round the promontory of Skagen, discovered about sixteen years after the birth of Christ the Island of Fionia or Fünen, and is even supposed to have reached the entrance of the Gulf of Finland. In the year 84 A.C. Julius Agricola, the conqueror of Britain, sailed for the first time round Scotland, and discovered the Orcadian Isles.

In Pliny's time the real magnitude of the earth was still so imperfectly known that, according to the calculations of that great though rather over-credulous naturalist, Europe occupied the third part, Asia only the fourth, and Africa about the fifth of its whole extent.

The geographer Ptolemy, who lived about the middle of the second century, under the reigns of Hadrian and Marcus Aurelius, describes the limits of the earth as far as they were known in his time. To the west, the coast of Africa had been explored as far as Cape Juby; and the Fortunate Islands or Hesperides, the present Canaries, rose from the ocean as the last lands towards the setting sun.

To the north discovery had reached as far as the Shetland Isles, and the promontory Perispa at the entrance of the Gulf of Finland; while on the east coast of Africa Cape Brava formed the ultimate boundary of the known world. Soon after Ptolemy's time the whole coast of Malacca (*Aurea Chersonesus*) and the Siamese Sea, as far as the Cape of Cambogia (*Notium promontorium*), was explored, and the Romans even appear to have had some knowledge of the great islands of the Indian archipelago, Java, Sumatra, and Borneo.

And yet, notwithstanding all this progress towards the East, it may well be asked whether the Phœnicians had not embraced a wider horizon than the Romans in the full zenith of their fortunes. Even though we reject the circumnavigation of Africa under Necho, and the discovery of America by Punic navigators, as not fully proved or fabulous, it is quite certain that they had explored the west coast of Africa to a much greater extent than the Romans, and extremely probable that they knew at least as much of the lands which bound the Indian Ocean. But, as from a narrow-

minded mercantile policy they kept many of their discoveries profoundly secret, all knowledge of them perished with their ruin. In ancient times, when the defeat of a people too often led to its complete destruction, or at least to the extinction of its peculiar civilisation, and the difficulties of intercourse rendered the diffusion of knowledge extremely difficult and slow, it not unfrequently happened that useful discoveries were erased from the memory of mankind, a danger which, thanks to the printing-press and the steam-engine, is now no longer to be feared.

Thus a darkening or eclipse of intellectual life took place to a vast extent when the western Roman Empire succumbed to the barbarians of the North, and the bands which for centuries had united the cities of the east and west were violently sundered. Under that fatal blight Civilisation vanished from the lands which had so long been her chosen seat, only to dawn again after a long and obscure night. Commercial intercourse ceased between the sea-ports of the Mediterranean, all communication with distant countries was cut off, and the boundaries of the known earth became more and more narrow, as the ignorance of a barbarous age increased.

It is not before the beginning of the ninth century that we perceive the first glimpses of a better day in the rising fortunes of some Italian sea-ports, where favourable circumstances had given birth to liberal institutions. As early as the year 840 Amalfi possessed a considerable number of trading-vessels, and carried on a lucrative commerce with the Levant. The maritime code of this little republic regulated the commercial transactions of all the Mediterranean sea-ports; as in a later century the law-book of Wisby served as a guide to the merchants of the Baltic. A few years after its submission in 1131 to the arms of King Roger of Sicily, Amalfi was plundered by the Pisanese and almost entirely destroyed. The neglected harbour was gradually choked with sand, and the little town, which now numbers no more than 3000 inhabitants, has nothing to console it for its actual poverty but the remembrance of a glorious past. Along with Amalfi, Gaëta, Naples, and Pisa, rose to considerable eminence in commerce, though far from equalling the power and splendour of Genoa and Venice, the great republics of northern Italy.

As far back as the beginning of the sixth century, the city of

the lagunes fits out a small fleet to purge the Adriatic of Istrian pirates. By a prudent course of policy she renders herself indispensable to the Byzantine court, and acquires great privileges in Constantinople. It is here she purchases the costly productions of the East, with which during the ninth and tenth centuries, she provides Northern Italy and a great part of Germany. About the beginning of the eleventh century her trade with Egypt and Syria begins to flourish, and soon raises her to the pinnacle of her power and wealth. In the year 1080 she extends her rule over Croatia and Dalmatia, and gains in 1204 considerable advantages by assisting the western crusaders in the conquest of Constantinople. Pera, numerous coast towns from the Hellespont to the Ionian Sea, a great part of the Morea, Corfu, and Candia fall to the winged lion's share, and requite the services of "blind old Dandolo." The silk manufacture is transported, as a valuable fruit of conquest, from the Morea to Venice, and becomes a new source of wealth to the Adriatic Tyre. The Euxine opens her ports to the Venetian seamen, treaties of commerce are concluded with Trebizond and Armenia, and a factory is established at Tana, at the mouth of the Don.

While thus the power of Venice rises more and more in the East, Genoa, which already in the tenth century carried on a flourishing trade, acquires by degrees the supremacy in the Western Mediterranean. The aid afforded by the republic to the Greek emperor Michael Palæologus contributes largely to the overthrow of the Latin throne of Constantinople, and opens the Bosphorus and the Black Sea to the enterprise of her merchants. The grandeur of Genoa now reaches its height; she holds fortified possession of Pera and Galata, and covers the coasts of the Crimea with her strong-holds and castles.

At a later period the Florentines appear on the scene, and assume the rank formerly held by Pisa in Mediterranean commerce. The acquisition of the sea-port of Leghorn (1421) opens the barriers of the ocean to the birthplace of Dante and Galileo.

After their deliverance from the Moorish yoke in the ninth century, a fresh and vigorous spirit begins also to animate the Catalans. They conclude treaties of commerce with Genoa and Pisa, and towards the end of the thirteenth century the ships of Barcelona are found visiting all the ports of the Mediterranean.

But in spite of the growth of trade and navigation in Italy and Spain, many years had yet to elapse after the fall of the Roman empire ere the gates of the Atlantic were once more opened to the navigators of the Mediterranean. It was not before the middle of the thirteenth century, after Seville and a great part of the Andalusian coast had been wrested from the Moors by Ferdinand of Castile, that the Italian and Catalonian seafarers, encouraged by privileges and remissions of duties, began to visit the port of Cadiz, where they met with merchants from Portugal and Biscay. Soon after, and most probably in consequence of the connexions thus formed, we find Italian ships visiting the ports of England and the Netherlands. About 1316, Genoese vessels began to carry goods to England; and somewhat later the Venetians, whose visits are not mentioned by the chroniclers before 1323.

Thus after a long interruption we see the seamen of the Mediterranean at length resuming the track to the Atlantic ports that had been struck out more than thirty centuries before by their predecessors the Phœnicians. But their voyages to the western ocean took place under circumstances much more favourable than those which had attended the men of Tyre and Carthage in their adventurous expeditions. Not only the better construction of their ships, but still more the use of the mariner's compass, for which Europe is probably indebted to the Arabs, who in their turn owed its knowledge to the Chinese, enabled them to steer more boldly into the open sea, and regardless of the bendings of the coasts to reach their journey's end by a less circuitous route. The period when the magnetic needle was first made use of by the Mediterranean navigators is not exactly known, but so much is certain that it did good service long before the time of Flavio Gioja (1302), to whom its discovery has been erroneously ascribed, though he may have introduced some improvement in the arrangement of the compass. Humboldt tells us in his "Cosmos," that in the satirical poem of Guyot de Provens, "La Bible" (1190), and in the description of Palestine by Jaques de Vitry, bishop of Ptolemais (1204 -- 1215), the sea-compass is mentioned as a well-known instrument. Dante also speaks of the needle which points to the stars (Paradise, xii. 29); and in a nautical work by Raimundus Lullus of Majorca, written in the year 1286, we find another proof of a much earlier

knowledge of the compass than before the beginning of the fourteenth century, since its use by the mariners of his time is expressly mentioned by that author.

Confidently following this unerring guide, the Catalonians sailed at an early period to the north coast of Scotland, and even preceded the Portuguese in their discoveries on the west coast of Africa, since Don Jayme Ferrer penetrated to the mouth of the Rio de Ouro as early as August 1346. About the same time the long-forgotten Canary Islands were rediscovered by the Spaniards; and at a later period (1402—1405) conquered and depopulated by some Norman adventurers, the Bethencourts.

While thus the South-European navigators unfurled their sails on the Atlantic, and gave the first impulse to the glorious discoveries that in the following century were destined to open up the ocean, and reveal its hitherto unknown greatness to mankind, the Indian Sea still remained closed to their enterprise; for though the Venetians by this time rivalled, if they did not surpass the ancient maritime greatness of the Tyrians in the Mediterranean, they did not, like them, directly fetch the rich produce of the South in their own ships from the East-African and Indian ports, but received them at second hand from the Arabian masters of Syria and Egypt.

But though no ship of theirs was ever seen in the Indian seas, through them the knowledge of the Arabian discoveries in those parts penetrated to Europe, and widely extended the knowledge of the ocean. For when the Arabs, fired by the prophetic ardour of Mahomet, suddenly emerged from the obscurity of pastoral life, and appeared as conquerors before the astonished world, the trade of the Indian Ocean fell into the hands of these new masters of the Red Sea and Persian Gulf, who soon learnt to pursue it with an energy which the Romans and Persians had never known. The town of Bassora was founded by the caliph Omar on the western shore of the great stream formed by the confluence of the Tigris and Euphrates, and soon emulated Alexandria herself in the greatness of its commerce. From Bassora the Arabs sailed far beyond the Siamese Gulf, which had formerly bounded European navigation. They visited the unknown ports of the Indian archipelago, and established so active a trade with Canton, that the Chinese emperor granted them the use of their own laws in that city.

This progress of the Arabs, and the vast treasures accruing to Venice from the overland Indian trade, could not fail to excite the envy of the other seafaring powers, and to call forth an increasing desire of discovering a new maritime route to the wealth-teeming regions of Southern Asia.

The wonderful narratives of the first travellers who wandered by land to the distant East likewise contributed in no small degree to foment the ardour of discovery. The most celebrated of these geographical pioneers was Marco Polo, a noble Venetian who had resided many years at the court of the Mongol ruler, Kublai Khan, and visited the most remote regions of Asia. He was the first European that ever sailed along the western shores of the Pacific, the first that told his astonished countrymen of the magnificence of Cambalu or Peking, the capital of the great kingdom of Cathay, and of the splendour of Zipanga or Japan situated on the confines of a vast ocean extending to the east. He also made more than one sea-voyage in the Indian Ocean, and to him Europe owed her first knowledge of the Moluccas, the east coast of Africa, and the island of Madagascar.

This greatest of all the mediæval travellers, who without exaggeration may be said to have enlarged the boundaries of the known earth as much as Alexander the Great, was followed by Oderich of Portenau, who travelled as far as India and China (1320—1330); by Sir John Mandeville, who visited almost all the lands described by Marco Polo; by Schildberger of Munich, who accompanied the barbarous Tamerlane on his locust expeditions; and finally by Clavigo, sent in the year 1403 by the Spanish court on an embassy to Samarcand. The truths which these bold travellers communicated to their countrymen about the riches and the commerce of the nations they had visited, as well as the fables in which their credulity or their extravagant fancy indulged, made an enormous impression on the European mind, and raised to a feverish heat the longing after those sunny lands and isles which imagination adorned with all the charms of an earthly paradise.

CHAP. XXIV.

Prince Henry of Portugal.—Discovery of Porto Santo and Madeira.—Doubling of Cape Bojador. — Discovery of the Cape Verde Islands. — Bartholomew Diaz. — Vasco de Gama.—Columbus.—His Predecessors.—Discovery of Greenland by Günnbjorn. — Bjorne Herjulfson. — Leif. — John Vaz Cortereal. — John and Sebastian Cabot.—Retrospective View of the Beginnings of English Navigation. — Ojeda and Amerigo Vespucci.—Vincent Yañez Pinson.— Cortez.—Verazzani. —Cartier.—The Portuguese in the Indian Oceán.

The reigning idea of a century finds always one or more eminent spirits, in whom and through whose agency the desires and hopes of thousands ripen into deeds, and are changed from dreams into realities. One of these rare and highly gifted men was Prince Henry of Portugal, a son of King John I., who made it the chief aim of his life to extend the boundaries of maritime discovery, and devoted with glowing ardour all the powers of his energetic mind, and all the influence of rank and riches to the attainment of this noble object. From the castle of Sagres near Cape St. Vincent, where, far from the court, he had fixed his residence in order to be less disturbed in his favourite studies, his eye glanced over the Atlantic, which constantly reminded him of the unknown lands which held out such brilliant prospects to the navigator who should venture to steer southwards along the African coast. The experienced seamen and learned geographers that surrounded him confirmed him in his hopes, and encouraged him to attempt the realisation of his generous ideas.

Fortunately all outward circumstances combined to favour the prince's projects. At that time Portugal was not plunged, as at present, in a state of slothful lethargy, but full of the bold and enterprising spirit which the expulsion of the Moors and long intestine wars had called to life. The geographical position of the country, bounded on every side by the dominions of a mightier neighbour, forbade all extension by land, and pointed to the ocean as the only field in which a comparatively small

but spirited people could hope to reap a rich harvest of wealth and glory.

The first two ships which Prince Henry sent out on a voyage of discovery along the African coast (1412) did not reach farther than Cape Bojador, whose rocky cliffs stretching far out into the Atlantic intimidated their inexperienced commanders. Six years later (1418) Juan Gonsalez Zarco and Tristan Vaz Tejeira were intrusted with a new expedition, and sailed with express commands to double that ill-famed promontory; but a terrible gale drove them out to sea, and forced them to seek a refuge on an unknown island, to which they thankfully gave the name of Porto Santo. This discovery, though extremely unimportant in itself, served to confirm the prince in his projects, and encouraged him to send out in the following year a new expedition under the same commander, to take possession of the island.

This led to a more important discovery, for on landing on Porto Santo the attention of the Portuguese was struck by a black and prominent spot, rising above the southern horizon. To this they now directed their course, and were equally delighted and surprised to see it swell out as they approached to the ample proportions of a large island; to which, on account of the dense forests which at that time covered its verdant hill-slopes up to the very top, they gave the name of Madeira. Prince Henry immediately equipped a considerable fleet to carry a colony of his countrymen to the new land of promise, and furnished them with the vine of Cyprus, and the sugar-cane of Sicily, which throve so well on the Atlantic isle, that after a few years the produce of Madeira began to be of consequence in the trade of the mother country.

Thus the first undertakings of Prince Henry were not left unrewarded; but, besides the commercial advantages arising from the possession of Madeira, it encouraged the Portuguese navigators no longer servilely to creep along the coasts, but boldly to steer into the open sea. Thus Don Gilianez, by avoiding the shore-currents, succeeded at last in doubling the dreaded Cape Bojador (1433), and opening a new sphere to navigation. One discovery now rapidly followed another. Gonsalez and Nuño Tristan (1440–1442) penetrated as far as the Senegal; Cape de Verd was reached in 1446; and three years later, the limits of

the known earth were extended as far as the islands of the same name and the Azores, those advanced sentinels in the bosom of the Atlantic. It may easily be imagined how much these successes contributed to encourage the universal ardour for discovery. Adventurers from all countries hastened to Portugal, hoping to gratify their ambition or avarice under the auspices of a prince who had already achieved so much; and even many Venetians and Genoese, who were at that time superior to all other nations in naval science, reckoned it as an honour to serve under a flag which might justly be considered as the high school of the seaman. Thus before Prince Henry closed his eyes (1463) the aim of his glorious life had been attained; for, though he did not live to see his countrymen penetrate into the Indian Ocean, yet he witnessed the mighty impulse which in a short time was to lead to that important result.

In the year 1471 the line was crossed for the first time, and the Portuguese thus detected the error of the ancients, who believed that the intolerable heat of a vertical sun rendered the equatorial regions uninhabitable by man.

Under John the Second a mighty fleet discovered the kingdoms of Benin and Congo (1484), followed the coast above 1500 miles beyond the equator, and revealed to Europe the constellations of another hemisphere.

The farther their ships penetrated to the south, the higher rose the flood tide of their hopes. As the African continent appeared sensibly to contract itself, and to bend towards the East as they proceeded, they no longer doubted that the way to the Indian Ocean would now soon be found, and give them the exclusive possession of a trade which had enriched Venice, and made that city the envy of the world. The ancient long-forgotten tale of the Phœnician circumnavigation of Africa now found belief, and Bartholomew Diaz sailed from Lisbon for the purpose of solving the important problem. The storms of an unknown ocean, the famine caused by the loss of his store-ship, and the frequent mutinies of a dispirited crew, could not stop the progress of this intrepid mariner, who, boldly advancing in the face of a thousand difficulties, at length discovered the high promontory which forms the southern extremity of Africa. But, as his weather-beaten ships were no longer able to con-

front the mountain-billows and furious gales foaming or roaring round that stormy headland, he was obliged, sore against his will, to give up the attempt to double the Cape of Tempests, Cabo tormentoso, as he called it, but to which the king gave the more inviting name of the Cape of Good Hope. Yet before Vasco de Gama set sail from Lisbon to accomplish the great work (1498) and win the prize to which so many navigators had gradually paved the way, the astounding intelligence had flashed through Europe that on the 12th of October, 1492, Columbus had discovered a new world in the west. The history of this most famous, and most important in its results, of all sea-voyages, is so well known that I may well refrain from entering into any details on the subject: at all events the reader will be much more interested by a short account of the intrepid navigators who, long before the great Genoese, found their way to the shores of the new continent.

While Tropical America is separated from Europe and Africa by a vast tract of intervening ocean, and even the advanced posts of the Azores and Cape de Verd Islands are far distant from the western shores of the Atlantic, Iceland and Greenland appear to us in the north as stations linking at comparatively easy distances the Old World and the New. It is, therefore, by no means surprising that the discovery of Iceland by the Norwegian *Viking* or pirate Nadod, and the somewhat later colonisation of the island by Ingolf, in the year 875, should in the following century have led the Norsemen to the discovery of America, particularly when we consider that no people ever equalled them in daring and romantic love of adventure:

> "Kings of the main their leaders brave,
> Their barks the dragons of the wave."

Greenland, discovered by Günnbjorn in the year 876 or 877, was indeed not colonised by the Icelanders before 983; a delay excusable enough when we consider the uninviting climate of that dreary peninsula or island, but three years after the latter date, we already find Bjorne Herjulfson undertaking a cruise from the new settlement to the south-west, and successively discovering Nantucket, Nova Scotia, and Newfoundland, though without making any attempts to land. Bjorne was followed

about the year 1000 by Leif, a son of Erick the Red, the founder of the Greenland colony; who, sailing along the American coast as far as $41\frac{1}{2}°$ north lat. discovered the *good Winland*, which received its name from the wild vines which Tyrker, a German who accompanied the expedition, found growing there in abundance. The fertility and mild climate of this coast, when compared with that of Labrador and Greenland, induced the discoverers to settle, and to found the first European colony on the American continent. Frequent wars with the Eskimos or Skrelingers (dwarfs), who at that time, as I have already mentioned in the fourth chapter, extended far more to the south than at present, soon however destroyed the colony; and the last account of Norman America we find in the old Scandinavian records is the mention of a ship which, in the year 1347, had sailed from Greenland to Markland (Nova Scotia) to gather wood, and was driven by a storm to Stamfjord on the west coast of Iceland. About this time also the colonies in Greenland, which until then had enjoyed a tolerable state of prosperity, decayed and ultimately perished under the blighting influence of commercial monopolies, of wars with the aborigines, and above all of the *black death* (1347–1351), that horrible plague of the fourteenth century, which, after having depopulated Europe, vented its fury even upon those remote wilds. Thus the knowledge of the Norman discovery of America gradually faded from the memory of man, and thus also it happened that the names and deeds of Leif and Bjorne Herjulfson remained totally unknown to the southern navigators, who at that time moreover, had little intercourse with the nations of Northern Europe.

Besides his well-authenticated Norman predecessors, Columbus may possibly have had others. Traces of early Irish and Welsh discoveries are pointed out by the Northern historians, and John Vaz Cortereal, a Portuguese navigator, is said to have visited the coasts of Newfoundland some time previous to the voyages of Columbus and Cabot.

If before the first voyage of the great Genoese navigator a mighty longing to penetrate to distant countries pervaded the public mind of Europe, it may be imagined to what a feverish glow this reigning idea of the century was excited, when the

wonderful accounts of the gold and enchanting beauty of Haiti spread from land to land. As in former times, half Europe had thrown itself upon the Orient to liberate the tomb of our Saviour from the tyranny of the Moslem; so now one flood of adventurers followed another to the new land of promise, which held out such glittering prospects of wealth and enjoyment. Obeying the mighty impulse, England and France now entered upon the path on which Portugal and Spain had so gloriously preceded them, and, as the fruit of this general emulation, we see after a few years the whole western shore of the great Atlantic basin drawn into the circle of the known earth.

If Columbus was undoubtedly the first discoverer of the West Indian islands (the Bahamas, Cuba, Haiti, 1492; Lesser Antilles, 1493; Jamaica, 1494), the honour of having preceded him on the American continent belongs to John Cabot, a Venetian merchant settled in Bristol, and to the youthful energy of his son Sebastian, since they landed on the coast of Labrador (24th June, 1497) seventeen months before the continent of Tropical America, in the delta of the Orinoco, was discovered by Columbus on his third voyage.

Thus Genoa and Venice, the great Mediterranean rivals, divide the glory of having revealed a new world to mankind, but it was ordained that the laurels of their sons should bloom under a foreign flag, and the fruits of their endeavours be reaped by other nations. For as Columbus steered into the western ocean in the service of the Spanish monarch, the Cabots were sent by Henry the Seventh of England across the Atlantic to discover a north-western passage to India. This, of course, they did not accomplish, but the discovery of Newfoundland and of the coast of America from Labrador to Virginia rewarded their efforts, and laid the foundation of Britain's colonial greatness. Their voyage is also remarkable as having been the first expedition of the kind that ever left the shores of England, which at that time held a very inferior rank among the maritime nations, and gave but faint indications of her future naval supremacy. On this occasion it may not be uninteresting to cast a retrospective glance on the modest beginnings of British navigation In the year 1217 the first treaty of commerce was concluded with Norway, and in the beginning of the fourteenth century Bergen

was the most distant port to which English vessels resorted. Soon afterwards they ventured into the Baltic, and it was not before the middle of the following century that they began to frequent some of the Castilian and Portuguese ports. Towards the end of the fifteenth century the English flag was still a stranger to the Mediterranean, and direct intercourse with the Levant only began with the sixteenth. Edward the Second, preparing for his great Scottish war, was obliged to hire five galleys from Genoa, the same town whence a few years back our giant steamers transported a whole Sardinian army to the shores of the Crimea, where centuries before the Genoese had been established as lords and masters. Such are the changes in the relative position of nations that have been brought about by the power of time!

After this short digression I return to America, where, in 1499, Ojeda and Amerigo Vespucci were the first to sail along the coast of Paria. The following year was uncommonly rich in voyages of discovery, as well in the south as in the north. In the western ocean the line was first crossed by Vincent Yañez Pinson, who doubled Cape Saint Augustin, discovered the mouths of the Amazon river, and thence sailed northwards along the coast as far as the island of Trinidad, which Columbus had discovered two years before. About the same time a Portuguese fleet, sailing under the command of Pedro Alvarez Cabral to the Indian Ocean, was driven by adverse winds to the coast of the Brazils; so that, if the genius of Columbus had not evoked, as it wêre, America out of the waves, chance would have effected her discovery a few years later.

A third voyage, which renders the year 1500 remarkable in maritime annals, is that of Gaspar Cortereal, a son of John Vaz Cortereal whom I have already mentioned as one of the doubtful precursors of Columbus.

Hoping to realise the dream of a north-west passage to the riches of India, Gaspar appeared on the inhospitable shores of Labrador, and penetrated into the Gulf of St. Lawrence. Storms and ice-drifts forced him to retreat, but firmly resolved to prosecute his design, he again set sail in the following year with two small vessels. It is supposed that on this second voyage he penetrated into Frobisher Bay, but here floating ice-

masses and violent gales separated him from his companion ship, which returned alone to Portugal.

As in our times the uncertain fate of Franklin has called forth a series of heroic deeds, so the doubtful destiny of the Portuguese explorer allowed his brother Miguel no rest, whom in the following spring we find hastening with three ships on the traces of the lost Gaspar. But Miguel also disappeared for ever among the ice-fields of the north. A third brother of this high-minded family yet remained, who earnestly implored the king that he also might be allowed to go forth and seek for his missing kindred. But Emanuel steadfastly refused permission, saying that these deplorable enterprises had already cost him two of his most valuable servants, and he could afford to lose no more.

In the year 1501 Rodrigo de Bastidas sailed to the coast of Paria, and discovered the whole shore-line from Cape de Vela to the Gulf of Darien. In the year 1502 the aged Columbus, entering with youthful ardour upon his fourth and last voyage, set sail with four wretched vessels, the largest of which was only seventy tons burthen, and discovered the coast of the American continent from Cape Gracias á Dios to Porto-Bello. The east coast of Yucatan was explored in the year 1508 by Juan Diaz de Solis and Vincent Yañez Pinson, and the island of Cuba circumnavigated for the first time by Sebastian de Ocampo.

In 1512 Juan Ponce de Leon is led by his evil star to Florida, where, instead of finding as he hoped the fountain of eternal youth, he is doomed to a miserable end; and in 1517 the above-mentioned Solis sails along the coasts of the Brazils to the mouth of the Rio de la Plata, where he is killed in a conflict with the Indians. In 1518 Cordova makes his countrymen acquainted with the north and west coasts of Yucatan, and in the same year Grijalva discovers the Mexican coast from Tabasco to San Juan de Ulloa. In 1518 he is followed by the great Cortez, who lands at Vera Cruz, overthrows the empire of Montezuma after a series of exploits unparalleled in history, and renders the whole coast of Mexico far to the north subject to the Spanish crown.

The voyages of Verazzani (1523) who sailed along the coast of the United States, and of Jacques Cartier (1524) who inves-

tigated the Bay of St. Lawrence, did not indeed widely extend geographical knowledge, as these navigators, who had been sent out by Francis I., did no more than examine more closely the previous discoveries of Cabot and Cortereal; their explorations however had the result of giving France possession of Canada, and of entitling her to a share in the fisheries of Newfoundland. Thus within half a century after the ever memorable day when Columbus first landed on Guanahani, we find almost the whole eastern coast of America rising into light from the deep darkness of an unknown past.

But while the western shores of the Atlantic were thus unrolling themselves before the wondering gaze of mankind, the Indian Ocean was the scene of no less remarkable events; for in the same year (1498) that Columbus first visited the American continent, Vasco de Gama doubled the Cape of Good Hope, which thus fully justified its auspicious name, crossed the Eastern Ocean, and on the 22nd of May landed at Calicut on the coast of Malabar, ten months and two days after leaving the port of Lisbon.

And now, as if by magic, the great revolution in commerce took place which the Venetians long had feared and the Portuguese had no less anxiously hoped for; for the latter lost no time in reaping the golden fruits of the glorious discoveries of Gama and his predecessors. In less than twenty years their flag waved in all the harbours of the Indian Ocean, from the east coast of Africa to Canton; and over this whole immense expanse a row of fortified stations secured to them the dominion of the seas. Their settlements in Diu and Goa awed the whole coast of Malabar, and cut off the intercourse of Egypt with India by way of the Red Sea. They took possession of the small island of Ormus, which commands the entrance of the Persian Gulf, and rendered this important commercial highway likewise tributary to their power. In the centre of the East-Indian world rose their chief emporium, Malacca, and even in distant China Macao obeyed their laws. The discovery of the Molucca Islands gave them the monopoly of the lucrative spice trade, which was destined at a later period, and more permanently, to enrich the thrifty Dutchman.

What vast changes had taken place since Prince Henry's first expeditions to the coast of Africa! How had old Ocean

enlarged his bounds! He who as a child had still known the earth with her old and narrow confines might, before his hair grew white, have seen the Atlantic assume a definite form; Africa project like an enormous peninsula into the boundless world of waters, and one single ocean bathe all the coasts from Canton to the West Indies.

Yet a few years and the Pacific opens its gates, and all the discoveries of Columbus and Vasco seem small when compared with the vast regions which Magellan reveals to man.

CHAP. XXV.

Vasco Nuñez de Balboa. — His Discovery of the Pacific, and subsequent Fate. — Ferdinand Magellan. — Sebastian el Cano, the first Circumnavigator of the Globe. — Discoveries of Pizarro and Cortez. — Urdaneta. — Juan Fernandez. — Mendoza. — Drake. — Discoveries of the Portuguese and Dutch in the Western Pacific.—Attempts of the Dutch and English to discover North-East and North-West Passages to India. — Sir Hugh Willoughby and Chancellor.— Frobisher.— Davis. — Barentz. — His Wintering in Nova Zembla. — Quiros. — Torres. — Schouten.—Le Maire.—Abel Tasman.—Hudson. —Baffin.—Dampier. —Anson. — Byron. — Wallis and Carteret. — Bougainville.

THE riches which the Indian trade had poured into the lap of Venice, and which at a later period fell to the share of the Portuguese, formed the chief incitement to the great maritime discoveries which illustrated the end of the fifteenth and the first half of the sixteenth century.

The hope to discover a new road to India had not only animated the Portuguese navigators, but also led Columbus and Cabot across the Atlantic. It caused the unfortunate Cortereal to sail into the Gulf of St. Lawrence, induced Juan de Solis to penetrate into the mouth of the Rio de la Plata, and was finally the chief end and aim of the wondrous expedition of Magellan. The time is now come when the barriers of the Pacific are to fall, but before crossing its vast bosom with the illustrious navigator who first traversed it from end to end, I shall detain the reader a few moments on the shores of the Gulf of Darien, where the wretched remains of the colony of Santa Maria el Antigua, founded by Ojeda in 1509, had, after the departure of that unfortunate adventurer, freely elected Vasco Nuñez de Balboa to be their governor. This great man, who would have emulated the fame of a Cortez or Pizarro if his good fortune had been equal to his merit, omitted no opportunity of justifying the choice of his comrades by the unremitting zeal he displayed for their welfare. Making up for the scantiness of his resources by unceasing activity, he subdued the neighbouring caciques,

and collected a great quantity of gold, which abounded more in that part of the continent than in the islands.

It happened during one of his frequent excursions that a young Cacique, witnessing a very angry dispute among the Spaniards about a few grains of gold, asked them in a contemptuous tone why they quarrelled about such a trifle; and added, that, if they set such an exorbitant value upon a metal comparatively worthless in his eyes, he could gratify their utmost wishes by pointing out to them a land where gold was so plentiful that even common utensils were made of it. And when Balboa eagerly asked where that happy country was situated, "Six days' journey to the south," was the answer, "will bring you to another ocean along whose coast it lies!"

This was the first time the Spaniards ever heard of the Pacific and of gold-teeming Peru, and the intelligence was well calculated to inflame the enterprising spirit of their leader. Balboa immediately concluded that this sea must be that which Columbus and so many other navigators had vainly sought for, and that its discovery would beyond all doubt open the way to India, which, according to the geographical error of the times, was supposed to be far less distant from America than it really is.

The most brilliant prospects rose before his fancy, and he would immediately have gone forth to realise them, if prudence had not warned him first to provide all the means necessary to insure success. He therefore endeavoured before all to gain the good-will of the neighbouring Indian chiefs, and sent some trustworthy agents to Hispaniola with a considerable quantity of gold, whereby many adventurers were induced to flock to his standard. Having thus reinforced himself, he thought he might now safely undertake his important expedition.

The Isthmus of Darien, over which he had to force his way, is not above sixty miles broad, but this short distance was rendered difficult, or rather impervious, by the innumerable obstacles of a tropical wilderness. The high mountains running along the neck of land were covered with dense forests, and the low grounds beneath filled with deep swamps, from which arose exhalations deadly to a European constitution. Wild torrents rushed down the ravines, and often forced them to retrace their steps. A march through a country like this, thinly peopled by a few

savages, and without any other guides than some Indians of doubtful fidelity, was an enterprise worthy of all the energies of a Balboa.

On the 1st of September, 1513, after the end of the rainy season, he set out with a small but well chosen band of 190 Spaniards, accompanied by 1000 Indian carriers. As long as he remained on the territories of the friendly Caciques his progress was comparatively easy, but scarce had he penetrated into the interior, when, besides the almost invincible obstacles of nature —forests, swamps, and swollen torrents,—he had to encounter the deadly enmity of the Indians. As he approached, some of the Caciques fled to the mountains, after having destroyed or carried along with them all that might have been of use to the hated strangers; while others, of more determined hostility, opposed his progress by force of arms. Although the Spaniards had been led to expect that a six days' march would bring them to their journey's end, they had already spent no less than twenty-five days in forcing their way through the wilderness, amidst incessant attacks and hardships. The greater part of them were rapidly giving way under fatigues almost surpassing the limits of mortal endurance, and even the strongest felt that they could not hold out much longer. But Balboa, ever the foremost to face danger or difficulty, whose spirits no reverse could damp, and whose fiery eloquence painted in glowing colours the glorious reward of their present privations, knew how to inspire his men with his own unconquerable spirit, so that without a murmur they kept toiling on through swamp and forest. At length the Indian guides pointed out to them a mountain-crest from which they promised them the view of the longed-for ocean. Filled with new ardour they climbed up the steep ascent, but before they reached the summit Balboa ordered them to halt, that he might be the first to enjoy the glorious prospect. As soon as he saw the Pacific stretch out in endless majesty along the verge of the distant horizon, he fell on his knees and poured forth his rapturous thanks to heaven for having awarded him so grand a discovery. And now also his impatient companions hurried on, and soon the primeval forest—accustomed only to the howlings of the brute or the eagle's scream — resounded with the loud exclamations of their astonishment, gratitude, and joy.

It was from the small mountain-chain of Quarequa, on the 25th of September, 1513, that the Spaniards first saw the sea-horizon, but they had still several days to march before they reached the Gulf of San Miguel. Here Alonzo Martin de Don Benito was the first white man that ever floated in a canoe on the Eastern Pacific, even before Balboa, armed with sword and shield, descended into the water to take possession of the newly discovered ocean in the name of the king his master.

Although the subsequent fortunes of this great man are foreign to my subject, yet it may not be uninteresting to the reader to be informed how his important services were requited. Unfortunately the ingratitude of the Spanish court, which so scandalously embittered the declining years of Columbus and Cortez, reached its lowest depth in the case of Balboa. Those great men had at least in the beginning enjoyed some show of favour, but the discoverer of the Pacific was treated throughout with the basest indignity. The governorship of Darien, to which his splendid achievements had given him so undeniable a claim, was conferred upon a certain Pedrarias Davila, a wretch who, after having persecuted and thwarted the hero in every possible way, caused him at length to be beheaded, under a false accusation of high treason.

Six years after Balboa had first seen the Pacific, two years after his execution, Ferdinand of Magellan made his appearance in that great ocean. A Portuguese of noble birth, this eminent navigator had served with distinction under Albuquerque, the conqueror of Malacca. His plan of seeking a new road to India across the Atlantic being but coldly received in his native country, he transferred his services to Spain, where his distinguished merit found better judges in Cardinal Ximenes, and his youthful master, Charles V. With five ships, the largest of which did not carry more than 120 tons, and with a crew of 236 men, partly the sweepings of the jails, he sailed on the 20th of September, 1519, from the port of San Lucar, and spent the following summer (the winter of the southern hemisphere) on the dreary coast of Patagonia. In this uncomfortable station he lost one of his squadron; and the Spaniards suffered so much from the excessive rigour of the climate, that the crews of three of his ships, headed by their officers, rose in open mutiny, and insisted on relinquishing the visionary project of a desperate

adventurer, and returning directly to Spain. This dangerous insurrection Magellan suppressed by an effort of courage no less prompt than intrepid, and inflicted exemplary punishment on the ringleaders.

He now continued his journey to the south, and reached, near 53° south lat., the celebrated straits which bear his name. Here again he had to exert his full authority to induce his reluctant followers to accompany him into the unknown channel that was to lead them to an equally unknown ocean. One of his ships immediately deserted him and returned to Europe, but the others remained true to their commander, and, after having spent twenty days in winding through those dangerous straits, they at last, on the 27th of November, 1521, emerged into the open ocean, the sight of which amply repaid Magellan for all the anxieties and troubles he had undergone. They now pursued their way across the wide expanse of waters, of whose enormous extent they had no conception, and soon had to endure all the miseries of hunger and disease. But the continuous beauty of the weather, and the steady easterly wind, which, swelling the sails of Magellan, drove him straight onwards to the goal, kept up his courage; and induced him to give to the ocean which greeted him with such a friendly welcome the name of the Pacific, which it still, though undeservedly, retains. During three months and twenty days he sailed to the north-west, and, by a singular mischance, without seeing any land in those isle-teeming seas, except only two uninhabited rocks which he called the "Desventuradas," or the "Wretched." At last, after the longest journey ever made by man through the deserts of the ocean, he discovered the small but fruitful group of the Ladrones (March 6, 1521), which afforded him refreshments in such abundance, that the vigour and health of his emanciated crew was soon reestablished. From these isles, to which his gratitude might have given a more friendly name, he proceeded on his voyage, and soon made the more important discovery of the islands now known as the *Philippines*. In one of these he got into an unfortunate quarrel with the natives, who attacked him in great numbers and well-armed; and, while he fought at the head of his men with his usual valour, he fell by the hands of those barbarians, together with several of his principal officers.

Thus Magellan lost the glory of accomplishing the first cir-

cumnavigation of the globe; the performance of which now fell to the share of his companion, Sebastian El Cano, who returned to San Lucar in the "Victoria" by the Cape of Good Hope, having sailed round the globe in the space of three years and twenty-eight days.

But although Magellan did not live fully to achieve his glorious undertaking, the astonishing perseverance and ability with which he performed the chief and most difficult part of his arduous task have secured him an immortal renown. Nor has posterity been unmindful of his services, having awarded his name an imperishable place in the memory of man, both in the straits, the portal of his grand discovery, and in the "Magellanic clouds," those dense clusters of stars and nebulæ which so beautifully stud the firmament of the southern hemisphere.

After Magellan, Pizarro, the conqueror of Peru, shines as a discoverer in the South Sea. The history of his memorable feats by land does not belong to this narrative, but I may well accompany him on his adventurous navigation along the unknown coast of South America, and relate the hardships he had to endure before he was enabled to reap the rewards of victory.

Soon after the execution, or rather the murder, of Balboa, Pedrarias Davila obtained permission to transfer the colony of Darien to Panama, which, although equally unhealthy, yet from its situation on the Pacific afforded greater facilities for the prosecution of discovery on the south-west coast, to which now all the hopes and plans of the Spanish gold-seekers were directed. Several expeditions left the new colony in rapid succession, but all proved unsuccessful. Their timorous leaders, none of whom had ventured beyond the dreary coasts of *Tierra firme*, gave such dismal accounts of their hardships and the wretched aspect of the countries they had seen, that the ardour for discovery was considerably damped, and the opinion began to gain ground that Balboa must have founded chimerical hopes on the idle tales of an ignorant or deceitful savage.

But there were three men in Panama, Francisco Pizarro, Diego de Almagro, and Hernando Luque, who, far from sharing the general opinion, remained fully determined to seek the unknown gold-land. Pizarro and Almagro were soldiers, Luque was a priest. They formed an association approved of by the governor, each agreeing to devote all his energies to the common interest.

Pizarro, the poorest of the three, took upon himself the greater part of the hardships and dangers of the enterprise, and volunteered to command the first expedition that should be fitted out; Almagro engaged to follow him with the necessary reinforcements; and Luque, the man of peace, promised to watch in Panama over the interests of the association.

On the 14th of November, 1524, Pizarro sailed from Panama with 112 men, closely packed together in one small vessel. Unfortunately he had chosen the worst season of the year for his departure, as the periodical winds raging at the time blew quite contrary to the course he intended to pursue, and thus it happened that after seventy days he had advanced no farther to the south-east than an experienced navigator will now traverse in as many hours. During this tedious journey he landed in different parts of the coast of Tierra firme, but, finding all the previous descriptions of its inhospitable nature fully confirmed, he saw himself obliged to await the promised reinforcements in Chuchama, opposite to the Pearl Islands. Here he was soon joined by Almagro, who had suffered similar hardships, and moreover lost an eye in a fight with the Indians. But, as he had advanced farther to the south, where the country and people wore a more favourable aspect, this slight glimpse of hope encouraged the adventurers to persevere in spite of all the miseries they had endured. Almagro returned to Panama, where with the greatest difficulty he could levy fourscore men, his sufferings and those of his companions having given his countrymen a very unfavourable idea of the service.

With this small reinforcement the associates did not hesitate to renew their enterprise, and at length, after a passage no less tedious than the first, reached the Bay of Saint Matthew on the coast of Quito (1526). In Tecumez, to the south of the Emerald River, they were delighted with the aspect of a fine well-cultivated country, inhabited by a people whose clothing and dwellings indicated a higher degree of civilisation and wealth. But, not venturing to attempt its conquest with a handful of men enfeebled by fatigue and disease, they retired to the small island of Gallo, where Pizarro waited, while Almagro once more returned to Panama, hoping that the better accounts he could give of their second journey would procure reinforcements large enough for the conquest of the newly discovered countries.

But the new governor of Panama, Pedro de los Rios, interdicted all further volunteering for an enterprise he considered chimerical, and even sent a vessel to the island of Gallo to bring back Pizarro and his companions. The associates, on the other hand, were less inclined than ever to give up their enterprise, now that better prospects had opened, so that Pizarro peremptorily refused to obey the governor's commands, and used all his eloquence in persuading his men not to abandon him. But the hardships they had endured, and the prospect of soon revisiting their families and friends, pleaded so strongly against him, that when he drew a line with his sword upon the sand, and told those that wished to leave him to pass over it, only thirteen of his veterans remained true to his fortunes.

With this select band of heroes Pizarro now retired to the desert island of Gorgona, where, as it lay further from the coast, he could await with greater security the reinforcements which he trusted the zeal of his associates would soon be able to procure. Nor was he deceived, for Almagro and Luque, by their repeated solicitations, at length prevailed upon the governor to send out a small vessel to his assistance, though without one landsman on board, that he might not be encouraged to any new enterprise. Meanwhile Pizarro and his faithful "thirteen" had spent five long months on their wretched island, their eyes constantly turned to the north, until, heart-sick and despairing from hope deferred, they resolved to intrust themselves to the inconstant waves upon a miserable raft, rather than remain any longer in that dreadful wilderness. But now at last the vessel from Panama appeared, and raised them so thoroughly from the deepest despondency to the most extravagant hopes, that Pizarro easily induced not only his old friends, but also the crew of the vessel, to sail farther to the south instead of returning at once to Panama.

This time the winds were favourable, and after a voyage of twenty days they at length reached the town of Tumbez on the coast of Peru, where the magnificent temple of the sun and the palace of the Incas, with its costly golden vases, exceeded their most sanguine expectations. But once more Pizarro, too weak to attempt invasion, was obliged to content himself with the view of the riches he one day hoped to possess, and returned to Panama after an absence of three years.

Amidst interminable delays and difficulties, which, although not to be compared to those he had endured, would still have totally discouraged a mind of a less iron mould, five years more elapsed before the matchless perseverance of Pizarro met with its reward. On the 14th of April, 1531, he landed in Peru for the second time, and in a few months the empire of the Incas lay prostrate at his feet. The poor adventurer of Gorgona was now one of the richest men on earth.

From this time the stream of conquest and discovery continuously rolled on to the south, so that after a few years the whole coast of Peru and Chili, as far as the wilds of Patagonia, was either known or subject to the Spaniards.

But while Pizarro and his comrades were thus opening the south-west coast of America to the knowledge of mankind, the conqueror of Mexico was no less anxious to add to his laurels the glory of discovery in the Northern Pacific, whose shores his warriors had reached in 1521, soon after the fall of the Aztec capital. Desirous of opening a new passage to the East Indies, he fitted out a fleet (1526), which, under the command of his kinsman Alvaro de Saavedra, was to sail to the Moluccas, and most likely discovered part of the Radack and Ralick Archipelago, visited and described three centuries later by Kotzebue and Chamisso.

In the year 1536 Cortez himself undertook a maritime expedition to the north, discovered the peninsula of California, and explored the greater part of the long and narrow bay which separates it from the mainland. After the return of this great man to Spain, where, loaded with ingratitude, he died in 1547, Rodriguez Cabrillo (1543) sailed as far as Monterey, and subsequently the pilot of the expedition, Bartholomew Ferreto, reached 43° N. lat., where Vancouver's Cape Oxford is situated.

In the year 1542 Villalobos made the first attempt to establish a colony on the Philippine Islands with settlers from Mexico, but, having failed, the colonisation did not take place before 1565. The intelligence of this success was brought to America by the pilot and monk, Fray Andreas Urdaneta, who sailed on the 1st of June from Manilla and arrived on the 3rd of October in the Mexican port of Acapulco. All previous attempts to sail from Asia to America had failed, on account of the opposing trade-winds; but Urdaneta sailed northward till he encountered

the favourable west wind, which carried him to the New World across the wide bosom of the Pacific. The discovery of this new ocean route was of considerable importance to the Spaniards, and, to perpetuate the memory of Urdaneta's nautical ability, they continued to call the passage by his name.

About the same time another Spanish pilot, Juan Fernandez, discovered the proper sea route from Callao to Chili, by first sailing far out to sea, and thus avoiding the coast-currents from the south. He also discovered the island which still bears his name, and has become so celebrated by the adventures of Alexander Selkirk, and the immortal tale of Daniel Defoe.

In the year 1567 an expedition sailed from Callao under Alvaro Mendana, which discovered the Solomon Islands; and in 1595 the group of the Marquesas de Mendoza was first brought to light by the same navigator. Before the last expedition of Mendana, Drake, the first circumnavigator of the globe (1577—1580) after Magellan and El Cano, penetrated into the Pacific, by rounding Cape Horn, and subsequently discovered the coasts of New Albion as far as 48° N. lat.

After having thus rapidly followed the course of the discoveries which during the sixteenth century made Europe acquainted with the whole western coast of America, from Cape Pillares in Tierra del Fuego to the mouth of the Columbia River, I return to the Indian Ocean, where in the beginning of the century we left the Portuguese in the full bloom of their power, and, to judge by the progress already made, likely to add largely to the stock of geographical knowledge. But whether the masters of the Indian Ocean had no desire to extend still farther the circle of their conquests, or the fiery spirit of enterprise which had animated Vasco de Gama and Diaz was prematurely extinguished, the discoveries of the Portuguese in the Pacific by no means corresponded to the gigantic flight which in less than a quarter of a century had led them from Cape de Verde to the extremity of the Malayan Archipelago. New Guinea was indeed discovered by Don Jorge de Menezes (1526) and Alvaro de Saavedra (1528), and some old maps prove that before 1542 a part of the coast of New Holland was known to the Portuguese, who had penetrated to the north as far as Formosa and Japan, yet at the end of the sixteenth century the western boundaries of the Pacific were only known from 40° N. lat. to 10° S. lat., and

all beyond was enveloped in darkness. As little was known of the innumerable South Sea islands, for although some of the groups had been seen or visited by the Spaniards, their existence was kept secret lest other seafaring nations should be tempted to explore the wastes of the Pacific.

I have already mentioned that the desire to find a shorter route to the wealth of India was the chief inducement which led to the discoveries of Vasco de Gama, Columbus, and Magellan; this same motive also called forth the first attempts of the Dutch and English to find a northern passage to the southern seas.

In the year 1553 Sir Hugh Willoughby and Chancellor left England on their memorable voyage of Arctic discovery, and steered to the north-east. In a stormy night they parted company, never to meet again. For a long time nothing was heard of Willoughby, until some Russian sailors found on the dreary coast of Lapland two wrecks tenanted only by the dead. A note, dated January 1554, proved that then at least some of the unfortunate navigators were still alive; but this was the last and only memorial of the mysterious end of the first Britons that ever ventured into the frozen seas. Chancellor was more fortunate. After having for a long time been driven about by storms, he discovered the White Sea, and on landing heard for the first time of Russia and her sovereign the Czar Ivan Vasiliovitch, who resided in a great town called Moscow. This unknown potentate the indefatigable seaman resolved to visit in his capital, where he was graciously received, and obtained permission for his countrymen to frequent the port of Archangel. Soon after his return to England he was sent back to Russia by Queen Mary, for the purpose of settling the terms of a treaty of commerce between the two nations; and, having satisfactorily accomplished his mission, once more set sail from the White Sea, accompanied by a Muscovite ambassador. But this time the return voyage was extremely unfortunate; two of the ships, richly laden with Russian commodities, ran ashore on the coast of Norway, and Chancellor's own vessel was driven by a dreadful storm as far as Pitsligo in Scotland, in which bay it was wrecked. Chancellor endeavoured to save the ambassador and himself in a boat, but the small pinnace was upset, and, although the Russian reached the strand, the Englishman, after having

escaped so many dangers in the Arctic Ocean, was doomed to an untimely end within sight of his native shores.

Twenty years afterwards, Martin Frobisher set sail with three small vessels of thirty-five, thirty, and ten tons, on no less an errand than the discovery of a north-west passage to Asia. With these wretched nutshells he reached the coasts of Greenland and Labrador, but was prevented by the ice from effecting a landing.

This first voyage was little remarkable in itself, but its accidental results tended much to the advancement of northern research, for Frobisher brought home some glittering stones, the lustre of which was erroneously attributed to gold; a circumstance which, as may well be imagined, greatly contributed to pave the way for a second expedition to "Meta Incognita." This time Frobisher sailed with three ships, of a much larger size, that they might be able to hold more of the anticipated treasure; and, besides securing 200 tons of the imaginary gold, discovered the entrance of the strait which bears his name.

His geographical knowledge may be inferred from the fact that he firmly believed the land on one side of this channel to be Asia, and on the other America; and, though we may be tempted to smile at his ignorance, yet the lion-hearted seaman is not the less to be admired, who with such inadequate means ventured to brave the unknown terrors of the Frozen Ocean.

The gales and floating ice which greeted Frobisher as he endeavoured to force a passage through the strait put a stop to all farther progress to India; but, as the gold delusion still continued, the expedition was considered eminently successful. A large squadron of fifteen vessels was consequently fitted out for the summer of 1578, and commissioned not only to bring back an untold amount of treasure, but also to take out materials and men to establish a colony on those desolate shores.

But this grand expedition, which sailed forth with such extravagant hopes, was doomed to end in disappointment. One of the largest vessels was crushed by an iceberg at the entrance of the strait, and the others were so beaten about by storms and obstructed by fogs, that the whole summer elapsed, and they were fain to return to England without having done anything for the advancement of geographical knowledge.

The utter worthlessness of the glittering stones having mean-

while been discovered, Frobisher relinquished all further attempts to push his fortunes in the northern regions, and sought new laurels in a sunnier clime. He accompanied Drake to the West Indies, commanded subsequently one of the largest vessels opposed to the Spanish Armada, and ended his heroic life while attacking a small French fort on behalf of Henry IV., during the war with the League. He was one of those adventurous spirits always thirsting for action, and too uneasy ever to enjoy repose.

In the year 1585, John Davis, with the ships "Sunshine" and "Moonshine," carrying besides their more necessary equipments a band of music "to cheer and recreate the spirits of the natives," made his first voyage in quest of the north-west passage, and discovered the broad strait which leads into the icy deserts of Baffin's Bay. But neither in this attempt nor in his two following ones was he able to effect the object for which he strove; and these repeated failures cooled for a long time the national ardour for northern discovery.

In the year 1594 the Dutch appear upon the scene. This persevering and industrious people, which in the following century was destined to play so important a part in the politics of Europe, had just then succeeded in casting off the Spanish yoke, and was laudably endeavouring to gain by maritime enterprise a position among the neighbouring states, which the smallness of its territory seemed to deny to its ambition. All the known roads to the treasures of the south were at that time too well guarded by the jealous fleets of Spain and Portugal to admit of any rivalry; but, if fortune should favour them in finding the yet unexplored northern passage to India, they might still hope to secure a lion's share in that most lucrative of trades. Animated by the bold spirit of adventure which the dawn of independence always calls forth in a nation, a company of Amsterdam merchants fitted out an expedition of northern discovery, which it intrusted to the superintendence and pilotage of William Barentz, one of the most experienced seamen of the day.

Barentz left the Texel on the 6th of June, 1594, reached the northern extremity of Nova Zembla, and returned to Holland. Meanwhile his associate, penetrating through a strait to which he gave the very appropriate name of Waigats or "Wind-hole," battled against the floating ice of the Sea of Kara, until, round-

ing a promontory, he saw a blue and open sea extending before him, and the Russian coast trending away towards the south-east. He now no longer doubted that he had sailed round the famous cape "Tabis" of Pliny, an imaginary promontory which according to that erroneous guide formed the northern extremity of Asia, and whence the voyage was supposed to be short and easy to its eastern and southern shores. He had only reached the Gulf of Obi, and within the Arctic Circle the continent of Asia still stretched 120 degrees to the east; but this was then unknown, and the Dutchman, satisfied with the prospect of success, did not press onward to test its reality, but started in full sail for Holland, to rouse the sluggish fancy of his phlegmatic countrymen with chimerical hopes and golden visions.

On the receipt of this glad intelligence six large vessels were immediately fitted out, and richly laden with goods suited to the taste of the Indians. A small swift-sailing yacht was added to the squadron to bear it company as far as the imaginary promontory of Tabis, and thence to return with the good news that it had safely performed what was supposed to be the most perilous part of the voyage, and had been left steering with a favourable wind right off to India.

But, as may well be imagined, these sanguine hopes were destined to meet with a woeful disappointment, for the Windhole Strait, doing full justice to its name, did not allow them to pass; and, after many fruitless endeavours to force their way through the mighty ice-blocks that obstructed that inhospitable channel, they returned dejected and crest-fallen to the port whence they had sailed a few months before, elated with such brilliant expectations.

Although great disappointment was felt at this failure, the scheme however was not abandoned, and on the 16th of May, 1596, Heemskerk, Barentz, and Cornelis Ryp once more started for the north-east. Bear Island and Spitzbergen were discovered, whereupon the ships separated; Cornelis and Heemskerk returning to Holland, while Barentz, enclosed by the ice, was obliged to spend a long and dreary winter in the dreadful solitudes of Nova Zembla. Fortunately a quantity of driftwood was found on the strand, which served the Dutchmen both for the construction of a small hut and for fuel. At the same time it raised their courage, as they now no longer doubted that Providence,

which had sent them this unexpected succour in the wilderness, would guide them safely through all their difficulties. And indeed they stood in need of this consolatory belief, for as early as September the ground was frozen so hard that they tried in vain to dig a grave for a dead comrade, and their cramped fingers could hardly proceed with the building of the hut.

The attacks of the white bears also gave them great trouble. One day Barentz, from the deck of the vessel, seeing three bears stealthily approaching a party of his men who were labouring at the hut, shouted loudly to warn them of their peril, and the men, startled at the near approach of danger, sought safety in flight. One of the party, in his haste and perturbation, fell into a cleft in the ice; but the hungry animals fortunately overlooked him, and continued their pursuit of the main body. These gained the vessel and began to congratulate themselves on their safety, when, to their horror, they perceived that their foes, instead of retreating from a hopeless pursuit, were actually scaling the ship's sides, evidently determined to have their meal. Matters now became serious. One of the sailors was despatched for a light, but in his hurry and agitation could not get the match to take fire (Enfields and revolvers were then unknown), and the muskets being thus rendered useless, the sailors in despair kept their enemies off by pelting them with whatever articles came first to hand. This unequal conflict continued for some time, until a well-directed blow on the snout of the largest bear caused the *barking** monster to retire from the field followed by his two companions,

> "who, seeing Hector flee,
> No longer dared to face the enemy."

By the middle of October the hut was completed; and though the accommodations it afforded were extremely scanty, they were glad to take up their abode in it at once.

And now began the long, dreary, three months' night of the 77th degree of latitude, during which snow-drifts and impetuous winds confined them to their miserable dwelling. "We looked pitifully one upon the other," says Gerret De Veer, the simple narrator of the sufferings of that Arctic winter, "being

* "I did not hear them roar as ours do, but they only bark." —*Marten's Voyage to Spitzbergen.*

in great fear that if the extremity of the cold grew to be more and more, we should all die there of cold; for that what fire soever we made would not warm us." The ice was now two inches thick upon the walls and even on the sides of their sleeping-cots, and the very clothes they wore were whitened with frost, so that as they sat together in their hut they "were all as white as the countrymen used to be when they came in at the gates of the towns in Holland with their sleads, and have gone all night."

Yet in the midst of all their sufferings these hardy men maintained brave and cheerful hearts, and so great was their elasticity of spirit that, remembering the 5th of January was "Twelfth Even," they determined to celebrate it as best they might. "And then," says the old chronicler, "we prayed our maister that we might be merry that night, and said that we were content to spend some of the wine that night which we had spared, and which was our share (one glass) every second day; and so that night we made merry and drew for king. And therewith we had two pounds of meale, whereof we made pancakes with oyle, and every man had a white biscuit, which we sopt in the wine. And so, supposing that we were in our own country, and amongst our friends, it comforted as well as if we had made a great banket in our owne house." Blessed Content! arising from a simple heart and a life of honest and healthful toil, never didst thou celebrate a greater triumph, or more forcibly show thy power, than in that dreary hut on Nova Zembla!

Some weeks afterwards the sun appeared once more above the horizon; and the glorious sight, though it soon vanished again into darkness, was a joyful one indeed, full of delightful images of a return to friends and home. Now, also, the furious gales and snow-storms ceased; and, though the severity of the cold continued unabated, they were able to brave the outer air and recruit their strength by exercise.

When summer came, it was found impossible to disengage the ice-bound vessel, and the only hopes of escaping from their dreary prison now rested on two small boats, in which they ventured on the capricious ocean. On the fourth day of their voyage, their fragile barks became surrounded by immense quantities of floating ice, which so crushed and injured them, that the crews, giving up all hope, took a solemn leave of each other. But in this desperate crisis they owed their lives to the

presence of mind and agility of De Veer, who with a well-secured rope leaped from one fragment of ice to another till he gained a firm field, on which first the sick, then the stores, the crews, and finally the boats themselves, were safely landed. Here they were obliged to remain while the boats underwent the necessary repairs, and during this detention upon a floating ice-field the gallant Barentz closed the eventful voyage of his life. He died as he had lived, calmly and bravely, thinking less of himself than of the safety of his crew, for his last words were directions as to the course in which they were to steer. Even the joyful prospect of a return to their families and home could not console his surviving comrades for the loss of their leader, whom they loved and revered as a friend and father. After a most tedious and dangerous passage, they at length arrived at Kola in Russian Lapland, where to their glad surprise they found their old comrade, John Cornelis, who received them on board his vessel and conveyed them to Amsterdam.

During the seventeenth century the most remarkable maritime discoveries were made by the English, Dutch, and Spaniards, though by the latter only at its commencement. In the year 1605 Quiros sailed from Callao, discovered the island of Sagittaria, since so renowned under the name of Otaheite, and the archipelago of Espiritu Santo, or the New Hebrides of Cook. On this journey he was accompanied by Torres, the bold seaman who some years after gave his name to the strait which separates New Guinea from Australia.

While the declining sun of Spain was thus gilding with its last rays the northern shore of New Holland, the meridian splendour of the Batavian republic cast forth bright beams of light over the wide Pacific.

Schouten and Le Maire, penetrating through the strait which is still named after the latter, sailed in the year 1616 round Tierra del Fuego; and about the same time Hartog discovered Eendragt's Land, on the west coast of Australia. The successive voyages of Jan Edel (1619), Peter Nuyts (1627), and Peter Carpenter (1628), brought to light the northern and southern shores of the vast island, which thus began to assume a rude shape on the map of the geographer. In the year 1642, Abel Tasman, the greatest of the Dutch navigators, drew a mighty furrow through the South Sea, discovered Van Diemen's Land,

which posterity desirous of perpetuating his fame has called Tasmania, saw the northern extremity of New Zealand emerge from the ocean, and finally unveiled to the world the hidden beauties of Tonga.

While the Dutch navigators were thus dissipating the darkness of Australia, Hudson and Baffin were immortalising their names in the Arctic Ocean.

In the year 1627 Henry Hudson made the first attempt to steer right on to the pole, and to cross to India over the axis of the globe. He reached the northern extremity of Spitzbergen, but all his attempts to penetrate deeper into the polar ocean were baffled by the mighty ice-fields that opposed his progress. But though he failed in his undertaking to sail through the region of eternal winter to the spicy groves of India, yet the numerous morsés and seals he had seen basking on the coast of Spitzbergen opened such cheering prospects of future profit, that the "Muscovy Company," which had fitted out the expedition, was by no means discontented with the issue of his voyage.

Three years after we find the gallant Hudson once more attempting to discover the north-west passage in a vessel of fifty-five tons, provisioned for six months. The crew which he commanded was unfortunately utterly unworthy of such a leader, and quailed as soon as they had to encounter the fog and ice-fields of the Frozen Ocean.

"And now there came both mist and snow,
And it grew wondrous cold;
And ice mast-high came floating by,
As green as emerald.

And through the drifts the snowy clifts
Did send a dismal sheen,
Nor shapes of men nor beasts we ken,
The ice was all between."

But, in spite of the murmurs and repinings of his faint-hearted followers, the dauntless commander pressed on through the strait which bears his name, until at last his little bark emerged into a boundless deep blue sea. Hudson's Bay lay before him, but the delighted discoverer was happy in the belief that the grand object of his voyage was attained, and the shortest road to India

laid open to the mariners of England. It was about the beginning of August, and the spiritless crew considering the passage accomplished, urged an immediate return; but Hudson was determined on completing the adventure, and wintering if possible on the sunny shores of India.

Three months long he continued tracking the coasts of that vast northern Mediterranean, now for the first time explored by civilised man, vainly hoping to see a new channel opening to the west, until at length November came and imprisoned his small vessel in adamantine fetters. A long and dreary winter awaited the ice-bound seamen, with almost exhausted provisions, and unfortunately without that heroic patience and serene concord which had sustained the sufferings of Barentz and his companions. It must indeed have been a melancholy winter for poor Hudson, solitary and friendless among scowling ruffians, hating him as the cause of their bitter misery; but spring came at last with its consolatory sunshine, and hope once more dawned in his tortured breast. The ship is again afloat, and on the 21st of June, 1611, the captain comes forth from his cabin, refreshed by the sleep of a quiet conscience, and strong in body and mind to meet the duties of the day. But as he steps on deck his arms are suddenly pinioned, and he finds himself in the power of a mutinous crew. He looks around for some trace of sympathy, but hatred meets him in every eye. Inquiry, remonstrance, entreaty, command, all alike fail to move their stubborn resolution, and now Hudson resigns himself bravely to his fate, with all the quiet dignity of a noble nature, and looks calmly at the ominous preparations going forward. A small open boat is in waiting, and into this he is lowered, some powder and shot and the carpenter's box come next, followed by the carpenter himself, a strong brave fellow, the captain's *one* devoted adherent among the rebellious crew; the sick and infirm complete the unfortunate cargo. A signal is given, the boat is cast adrift, and soon the last faint cry for mercy expires in the breeze which carries the vessel onwards on its homeward course.

Thus perished the high-minded Hudson, without further tiding or trace, on the scene of his glory; but the vengeance of heaven soon overtook the ringleaders of that dark conspiracy. Some fell in a fight with the Eskimos, and others died on the

homeward voyage, which was performed under the extremity of famine. Whatever horrors may have attended the last moments of Hudson, his sufferings were less, for his conscience was undefiled by guilt.

In the year 1616 Baffin sailed round the enormous bay to which his name has been given, but without attempting to penetrate through any one of those wide sounds that have led the Arctic navigators of our days to so many glorious discoveries.

From the times of Tasman, whose bold voyage through the wastes of the Southern Pacific has already been mentioned, to those of our own immortal Cook, but very little was done for the progress of geography, as if, after so many heroic endeavours, the spirit of maritime discovery had required a long repose to recruit its energies, ere the greatest navigator of modern times was destined to unveil the mysterious darkness which still concealed one half of the vast Pacific from the knowledge of mankind. The voyages most worthy of remark during this period were those of the Cossack Semen Deshnew (1654), who sailed from the mouth of the Kolyma River round the eastern promontory of Asia, and must be considered as the discoverer of Behring's Straits; of the adventurous Dampier (1689—1691), that strange combination of the buccaneer, the author, and the naturalist, who first discovered the strait which separates New Guinea from New Ireland; of the Dutchman Roggewein (1721—23), who made known some islands in the Pacific; of the brothers Laptew and of Prontschitschew (1734—1743), who unveiled the greatest part of the Siberian coast; of Commodore Anson (1740—1744), whose heroic sufferings and successes in the Pacific still live in the memory of his countrymen; and of the unfortunate Behring (1730—1741), who terminated his second unsuccessful exploring expedition by a miserable death on a desert island.

After the peace of Aix la Chapelle England felt that the dominion of the seas imposed upon her the obligation of extending the bounds of geographical knowledge, and thus in rapid succession Byron (1764) and Wallis and Carteret (1766—1768) were sent forth to discover unknown shores, while France made a simultaneous effort to refresh the somewhat meagre laurels she

had reaped by the voyages of Verazzani and Cartier. The consequences of this emulation were not unimportant. Bougainville (1766—1768) completed the discovery of the Solomon Islands, which Mendana had only partly seen; Wallis made the world acquainted with the beauties of Tahiti, and Byron explored the unvisited coasts of Patagonia. But the fame of these worthy mariners was soon eclipsed by a greater renown, for, in the same year that Wallis returned from his expedition, Cook sailed from the port of Plymouth on his first voyage round the world.

CHAP. XXVI.

What had Cook's Predecessors left him to discover?—His first Voyage.—Discovery of the Society Islands, and of the East Coast of New Holland.—His second Voyage.—Discovery of the Hervey Group.—Researches in the South Sea.—The New Hebrides.—Discovery of New Caledonia and of South Georgia.—His third Voyage. — The Sandwich Islands. — New Albion. — West Georgia. — Cook's Murder.—Vancouver.—La Peyrouse.

To form a correct estimate of Cook's discoveries, it is necessary that, before following the track of that great seaman, we should glance over the vast regions of the Pacific previously unknown to man. Many navigators indeed, since Magellan, had traversed that immense ocean, but the greater part of its expanse still lay buried in obscurity.

To the north of the line, the Spaniards, sailing from Manilla to Acapulco, still servilely followed the route which Urdaneta had pointed out, and all beyond was unexplored.

The regions to the south of the line were better known, but here also maritime discoverers, with the sole exception of Tasman, had confined themselves to the tropical waters. No one had yet tried to sail through the boundless space which to the south of the 25th degree of latitude extended between New Zealand and America. Of Australia only the western coast was known; the existence of Torres' Strait had long since been forgotten, and New Guinea and New Holland were supposed to form one connected land. To the south no one knew whether Australia and Van Diemen's Land were joined together, or severed by a channel; and the eastern coast of the fifth part of the world still awaited a discoverer. The boundaries of New Zealand were buried in the same obscurity. Tasman had only visited the west coast of the northern island, which, as far as was then known, might have extended a thousand miles farther on towards Chili. In one word, the great geographical problem of an enormous southern continent, the existence of which was formerly supposed necessary to form the counterpoise of the northern lands, still

remained unsolved. The discoveries already made had indeed narrowed the limits which during the sixteenth century were still assigned to that imaginary continent, but in the unexplored bosom of the South Sea there yet was room enough for lands surpassing the whole of Europe in extent. Many of the South Sea islands moreover, though discovered before Cook's voyages, had vanished again from the memory of the world, or, according to Humboldt's expression, "wavered, as if badly rooted on the map, for want of exact astronomical measurements." Thus two hundred and fifty years after Magellan the Pacific still offered an enormous field for discovery, and when Cook set sail on the 30th of July, 1768, on his first voyage of circumnavigation, nearly one half of the globe lay open to his researches.

The first service he rendered on this voyage was the discovery that the route to the Pacific through the Strait of Le Maire and round Cape Horn was preferable to that which until then had been followed, through the Straits of Magellan.

After having observed at Otaheite the transit of Venus across the sun, which was one of the chief objects of the expedition, he soon after landed on the shores of Huaheine, Ulietea, and Borabora, which had never yet been visited by a European mariner, and gave to the whole group the name of the Society Islands, on account of their close vicinity to each other. Thence he sailed to New Zealand, which he was the first to find consisted of two large islands, separated by the strait which bears his name. With unwearied industry he spent no less than six months on the accurate survey of the New Zealand group, and then sailed to New Holland, the eastern coast of which he first discovered, and closely examined in its full length of 2000 miles. He also found that the continent of Australia was separated from New Guinea by a channel which he called "Endeavour Strait," but to which the justice of posterity has restored or awarded the name of Torres, its first explorer. This whole sea is so full of dangerous reefs and shoals that for months the sounding line was scarce ever laid aside, and any less experienced and prudent navigator must inevitably have been wrecked during these constant cruises in such perilous waters. Even Cook owed more than once his preservation to what may well be called a miraculous interposition of Providence, of which I shall cite a remarkable example. It was on the 10th of June, 1770, in the latitude of Trinity Bay. The

vessel sailed, under a fresh breeze and by clear moonlight, through a sea the depth of which the plummet constantly indicated at 20 to 21 fathoms, so that not the least danger was apprehended. But suddenly the depth diminished to four fathoms, and before the lead could be heaved again the vessel struck and remained immoveable, except as far as she was heaved up and down and dashed against the rocks by the surge. The general anxiety may be imagined, and indeed the situation was such as to warrant the most serious apprehensions. It was found that the ship had been lifted over the ledge of a rock and lay in a hollow, inside of the reef, where the water in some places was three or four fathoms deep and in others hardly as many feet. The sheathing boards were knocked off and floating round the ship in great numbers, and at last the false keel also was destroyed, while the constant grating of the vessel against the rock seemed to announce its speedy disruption. It was now necessary to lighten the vessel as much as possible, and soon more than 50 tons' weight was thrown overboard.

On the following morning land was seen at the distance of eight miles; but no islet lay between, on which, in case the vessel went to pieces, a speedy refuge might be found. To add to their distress, the vessel drew so much water that three pumps could hardly master it; and, finally, it was found that even the rising of the flood, on which they mainly reckoned, was unavailing to extricate them from their perilous position. All that could possibly be spared was now therefore cast into the sea, still more to lighten the vessel, and thus the next tide was patiently expected, when, after incredible exertion, the ship righted, and they got her over the ledge of the rock into deep water.

But the men were by this time so much exhausted by their uninterrupted labour that they could not stand to the pumps more than five or six minutes at a time, after which they threw themselves flat on the streaming deck, where they lay till others exhausted like themselves took their places, on which they started up again and renewed their exertions. In this desperate situation one of the midshipmen, named Monkhouse, bethought himself of a means by which a ship, having sprung a leak admitting more than four feet of water in an hour, had yet been able to perform the whole journey from Virginia to London. He

took a lower studding-sail, and, having mixed a large quantity of oakum and wool together, stitched them down by handfuls as lightly as possible. The sail was then hauled under the ship's bottom by means of ropes which kept it extended. When it came under the leak, the wool and oakum, with part of the sail, were forced inwards by the pressure of the water, which thus prevented its own ingress in such an effectual manner that one pump, instead of three, was now sufficient to keep it under. In this way they got the ship into a convenient port on the coast of New Holland, where they repaired the injury. Here it was found that their preservation was not entirely owing to that ingenious expedient, for one of the holes in the ship's bottom was almost entirely plugged by a piece of rock which had broken off and stuck in it; and this hole was so large, that, had it not been filled up in this truly extraordinary manner, the vessel must undoubtedly have sunk. Some persons, leading a tranquil life unvexed by storm or wave, might perhaps be inclined to ascribe so miraculous an escape to chance, but the seaman, who has had death before his eyes, will always in such a case recognise the hand of an Almighty protector: and who can doubt that a thrill of intense gratitude flashed through the soul of Cook on the discovery of the cause to which he owed the preservation of his life?

With a vessel thus shattered, and a crew thus worn with fatigue, further discoveries were no more to be thought of, and Cook hastened to return by way of Batavia and the Cape to England, where he arrived on the 11th of June, 1771.

The object of his second voyage (1772—1775) was to determine finally the question of the existence of a great southern continent, and to extend the geography of that part of the globe to its utmost limits. Sir Joseph Banks and Dr. Solander had accompanied him on his first voyage, this time John Reinhold Forster and his son George were engaged by government to explore and collect the natural history of the countries through which they should pass.

On the 13th of July, 1772, Cook sailed from Plymouth, and reached the Cape without having a single man sick. Well aware how much cleanliness and pure air contribute to health, he had neglected none of the means necessary to insure it. Every day the beds were aired, the linen of the sailors was

frequently washed, and in rainy weather fire often made between decks, to dispel unwholesome damps and effluvia.

He now sailed to the south far into a desert and unknown sea, crossed it in various directions, and after having spent 117 days on the ocean, mostly among floating ice-fields, and without having once seen land, he steered northwards to the well-known coast of New Zealand, where on the 25th of January, 1773, he cast anchor in Dusky Bay. The feelings of the seaman may be imagined, when, after long wanderings over the waste of waters, he sees land, mountains, forests, and green plains rise above the horizon, when singing-birds take the place of the wild sea-mew, and friendly faces greet him on the strand. A beneficent mind is ever anxious to do good, and thus before sailing farther on to Otaheite, Cook caused a little garden to be planted, in which European vegetable seeds were sown and confided with proper instructions to the care of the intelligent savages, who were moreover presented with goats and pigs.

On the return voyage from Tahiti to New Zealand, where he intended to provide himself with fire-wood and provisions, before advancing once more into the high southern latitudes, he was pleased with the discovery of the small but lovely Harvey Islands, whose green girdle of cocoa-nut palms mirrors itself in the dark blue waters.

And now again he cruised in all directions through the icy sea, over an extent of 65° of longitude and as far as the 71st degree of southern latitude, without having seen any land; and having thus satisfied himself of the non-existence of a southern continent, or at least of its circumscription within bounds which must ever render it perfectly useless to man, he left those dreary regions of eternal winter, to continue his discoveries under a less inclement sky.

He first visited Easter Island and the Marquesas, where a new discovery received the name of Hood's Island, and on the way thence to Tahiti added the Palisser Group to the map of the world. We now follow him to the extensive archipelago of Espiritu Santo, first seen by Quiros in 1606, who took it for a part of the imaginary southern continent. Since then it had only been visited by Bougainville (1768), who however had contented himself with landing on the Isle of Lepers, and ascertaining the fact that it did not form part of a continent but

of a considerable group of islands. Cook on his part examined the whole archipelago in such an accurate manner, ascertaining the situation of many of the islands and discovering such numbers of new ones, that he justly thought he had acquired the right to rebaptize them under the name of the New Hebrides.

From these islands he sailed for the third time to New Zealand, and discovered on his passage New Caledonia and the romantic Norfolk Island.

Leaving New Zealand on the 10th of November, 1774, once more to search for the southern continent, he traversed a vast extent of sea for 17 days, from 43° to 55° 48′ S. lat., when he gave up all thoughts of finding any more land in that part of the ocean, and determined to steer directly for the west entrance of the Straits of Magellan, with a design of coasting the southern part of Tierra del Fuego, quite round Cape Horn to Le Maire's Straits. Those wild, deeply indented, rocky coasts, the region of eternal storms and fogs, form the most striking contrast to the smiling shores of the South Sea islands. But, if in the latter the splendour of tropical vegetation enchants the eye of the spectator, the exuberance of animal life in the Magellanic Archipelago may well raise his astonishment. In one of the small islands near Staaten Land Cook admired the remarkable harmony reigning among the different species of mammifera and birds. The sea-lions occupied the greatest part of the sea-coast, the bears the inland; the shags were posted on the highest cliffs, the penguins in such places as had the best access to the sea; and the other birds chose more retired places. Occasionally, however, all these animals were seen to mix together like domestic cattle and poultry in a farmyard, without one attempting to hurt the other in the least. Even the eagles and the vultures were frequently observed sitting together on the hills among the shags, while none of the latter, either old or young, appeared to be disturbed at their presence. No doubt the poor fishes had to pay for the touching union of this "happy family."

Having fully explored the southern extremity of America, we once more see the indefatigable navigator steer forth into the deserts of the southern Polar Ocean, where he discovers some snow-clad isles, Bird Island, South Georgia, Sandwich Land,

the southern Thule; and finally returns to England (30th July, 1775) after an absence of three years and seventeen days.

His third voyage (1776) was undertaken for the purpose of exploring the Northern Pacific, and casting the same broad light over those unvisited waters as over the southern part of that vast ocean. To the south-east of the Cape of Good Hope he discovered Prince Edward's Islands, and thence proceeded to explore Kerguelen's Land, discovered six years previously by the Frenchman of that name. This wintry island bears neither tree nor shrub, but in the bays the gigantic seaweeds form submarine forests, and countless penguins make the dreary shores resound with their deep braying voice.

Van Diemen's Land, New Zealand, and the Friendly and Society Isles were now visited for the last time. Steering to the north, Cook discovered in the last days of the year 1777 the Sandwich Islands, most likely previously known to the Spaniards, but kept secret from the world; and reached on the 7th of March, 1778, the mountainous forest-girt coast of New Albion, along which two centuries before Drake had sailed as far as 48° N. lat. Penetrating farther and farther to the north, he at length reached the most westerly point of the American continent, Cape Prince of Wales, which, stretching far out into the Straits of Behring, is only thirty-nine miles distant from the east coast of Siberia. Both pillars of this water-gate, according to Chamisso's description, are high mountains within sight of each other, rising abruptly from the sea on the Asiatic side, while on the American their foot is bordered by a low alluvial plain. On the Asiatic side the sea has its greatest depth, and the current, which sets from the south into the channel with a rapidity of two or three knots an hour, its greatest strength. Whales and numberless herds of walruses are seen only on the Asiatic side.

Through these famous straits, which Deshnew had first passed, and which Behring most likely never saw, Cook penetrated into the Arctic Ocean, examined a part of the Siberian coast, and then sailed to the opposite shores of America, where he discovered and explored the coast of West Georgia as far as 70° 44 N. lat., until fields of ice opposed an impenetrable barrier to his progress.

After having thus illumined with the torch of science the farthest extremities of the earth, Cook once more steered to the south and discovered Hawaii, the largest of the Sandwich Islands. But better had it been for him if the glory of this discovery had fallen to the share of some other navigator, for it was here that the illustrious seaman, who had thrice circumnavigated the globe, was doomed to fall by the club of a barbarous savage.

No navigator has ever made so many important discoveries at such distances from each other as Cook, or done more for the progress of geographical knowledge. The wide Pacific he so thoroughly explored, that his successors found only single ears to glean where he had reaped the richest harvest. With the firm resolution and the indomitable perseverance of the ancient mariners who preceded him on that vast ocean, he combined a scientific knowledge they never possessed. What they had only flightily observed, or imperfectly described, he in reality discovered, and indelibly marked upon the map of the globe. Indefatigable with the astrolabe and the plummet, he neglected no opportunity of pointing out to his successors both the dangers they would have to avoid, and the harbours in which they might find a refuge against storms, and a supply of fresh water and provisions. His excellent method of preserving the health of seamen from the murderous attacks of the scurvy, secures him a lasting place among the benefactors of mankind. But he not only anxiously watched over the welfare of his companions—his humanity extended a no less salutary influence over the savages with whom he came in contact. He everywhere sought to better their condition, made them presents of useful animals and seeds, and pointed out to them the advantages of peace and agriculture. But his chief praise remains yet to be told, and this is, that he owed the high position he acquired in life exclusively to himself. He whose fame reached as far as the limits of the civilised world, and whose death was mourned as a national calamity, was the son of a poor labourer, and had commenced his career as a common sailor.

The most celebrated navigators during the last quarter of the eighteenth century were Vancouver and La Peyrouse.

Vancouver, who had accompanied Cook on his last and fatal voyage, gained his chief laurels (1790) by thoroughly exploring the north-west coast of America, which his illustrious friend had

merely sketched in its most important outlines, having been prevented by his untimely end from investigating it more fully on a second visit. Vancouver began his hydrographical labours at Cape Mendocino, examined the Straits of Juan de Fuca, and, having convinced himself of the non-existence of a passage to the eastward, accurately investigated the labyrinth of bays, isles, sounds, and inlets, extending between 50° and 60° N. lat., thus establishing the important fact of the uninterrupted continuation of the American continent in these parts. Vancouver's Island will transmit his name to the latest posterity, and British Columbia remember him as the first navigator that accurately mapped her shores.

The fame of La Peyrouse is owing more to his misfortunes than to his eminent services. After having distinguished himself as a naval officer, he was sent by the equally unfortunate Louis XVI. on the voyage of discovery from which he was never to return. On the coast of Tartary and in the Japanese seas he examined a part of the world which hitherto no European had visited, and after having rectified many geographical errors sailed to Botany Bay, whence he forwarded his last despatches (7th Feb. 1788) to Europe. With the design of sailing through Torres' Straits to the Gulf of Carpentaria, he left the new-born English colony, but disappeared in the trackless ocean, and years and years passed on without solving the mystery of his fate.

At length, in 1826, Captain Dillon, an Englishman, was informed by Martin Bushart, a Prussian sailor whom he found settled on the Island of Tikopia, that many years since two large ships had been wrecked on the neighbouring Island of Vanikoro. Having brought this intelligence to Calcutta, he was sent out by the East India Company in the "Research" to make further inquiries on the scene of the catastrophe. On the 13th of Sept., 1827, Dillon anchored at Vanikoro, and, having collected the most interesting relics of the shipwreck, left it after a few weeks.

These facts became known at Hobart Town to the French circumnavigator Dumont d'Urville, who immediately resolved to sail to Vanikoro. He arrived there on the 22nd Feb., 1828, but at first found it very difficult to persuade the suspicious natives to point out to him the remains of the wrecked ship, until the offer of a piece of red cloth effectually overcame their scruples.

One of the boldest immediately jumped into a boat and offered to guide them on condition of receiving the proffered reward. The bargain was gladly struck, and the Frenchmen, piloted by the negro, eagerly pushed off from shore.

The coral reef which forms an enormous girdle round Vanikoro approaches the land opposite to the village of Paiou, so that the distance between them is hardly a mile. There, in a channel dividing the breakers, the savage caused the boat to stop, and made signs to the Frenchmen to look down to the bottom, where they saw anchors, cannons, and other objects scattered about and overgrown with corals. No doubt now remained, and with deep emotion they gazed on these last memorials of the unfortunate expedition of La Peyrouse. Metal alone had been able to resist the tooth of time, the rolling waters, or the gnawing ship-worm; all wood-work was gone.

I have already stated that on D'Urville's arrival he found the natives extremely distrustful and shy, answering all his questions by negations. It was evident that their conduct towards La Peyrouse had been anything but hospitable, and that they now feared the tardy vengeance of the white men. But, finding themselves treated with invariable kindness, their fears gradually gave way, and thus it became possible to gather some information about the catastrophe from some old men who had witnessed it, and from the most intelligent of the chiefs.

After a dark and stormy night the islanders saw early on the following morning an enormous *pirogue* stranded on the coral reef on the south side of the island. The surf soon destroyed the ship, and but a small number of the crew reached the shore in a boat. On the following day a second large *pirogue* stranded opposite Paiou. But this wreck lying on the lee-side of the island, less exposed to the surf, and resting on a more even ground, remained a longer time without going to pieces. The whole of the crew escaped in the boats to Paiou, where they built a small vessel, and after a stay of five months once more embarked, and were never heard of since. Most likely they had steered towards New Ireland, with the intention of ultimately reaching the Moluccas or the Philippine Islands, and perished on some unknown reef. The unhealthy condition of D'Urville's crew prevented him from extending his researches any further along the western coasts of the Solomon Islands. That the

stranded vessels were those of La Peyrouse is beyond all doubt; for years before and after no other large vessels had been lost in those seas. The heavy cannons could only have belonged to ships of war such as La Peyrouse commanded, and several of the instruments collected by Captain Dillon evidently belonged to a scientific expedition.

Before D'Urville left Vanikoro he resolved to raise a simple monument to the memory of his unfortunate countrymen, a four-sided pyramid resting on a square base. Neither nails nor iron clasps fastened the coral blocks together, for fear of awakening the cupidity of the savages; and, if they have kept their word to honour the *Papalangi* monument as they would a temple erected to their own gods, it still reminds the navigator whom chance may lead to that secluded island, of the renown and tragical end of the ill-fated La Peyrouse.

CHAP. XXVII.

Scoresby.—The Arctic Navigators.—Ross.—Parry.—Sufferings of Franklin and his Companions on his Overland Expedition in 1821.—Parry's Sledge-journey to the North Pole.—Sir John Franklin.—M'Clure.—Kane.—M'Clintock.—South Polar Expeditions.—Billinghausen.—Weddell.—Biscoe.—Balleny.—Dumont d'Urville.—Wilkes.—Sir James Ross.—Recent scientific Voyages of Circumnavigation.

Although the undaunted courage and indomitable perseverance of the great navigators whom I have named in the preceding chapters had gradually circumscribed the bounds of discovery, and no vast ocean remained to be explored by some future Cook or Magellan, yet at the beginning of this century many secrets of the sea still remained unrevealed to man.

The north coast of America and the Arctic Ocean beyond were still plunged in mysterious darkness; and although Cook in several places had advanced far into the Antarctic seas, yet here also a wide field still lay open to the adventurous seaman.

Many coasts, many groups of islands scattered over the vast bosom of the ocean, awaited a more accurate survey, and would no doubt have remained unexplored, if gold, as in former times, had still been the sole magnet which attracted the seafarer to distant parts of the world. But fortunately science had now become a power which induced man, without any prospect of immediate profit, to spare no expense and to shrink from no danger, that he might become better and better acquainted with his dwelling-place the earth.

It cannot be denied that our century has laboured at the solution of all these various geographical questions with an energy and perseverance unexampled in the history of civilisation; and the prominent part she has taken in their investigation is undoubtedly one of the great glories of England. At no other time have more voyages of discovery and more scientific expeditions been undertaken; never have more courageous Argonauts gone forth to conquer the golden fleece of knowledge. It

will be the pleasing task of this closing chapter to follow these noble mariners in their adventurous course; and, to avoid confusion, I shall begin with a short history of Arctic discovery up to the present day, and afterwards treat of the efforts made to extend our knowledge towards the South Pole. In spite of the unsuccessful efforts of a Frobisher, a Davis, a Hudson, and a Baffin, England had never given up the hope of discovering a northern passage to India, either direct across the Pole, or round the north coast of America. It had been one of the chief objects of Cook's third voyage to find a sea-path from Behring's Straits to Baffin's or Hudson's Bay; and some years before, while the illustrious navigator was busy exploring the Southern Pacific, we see Captain Phipps renewing the old attempt to sail direct to the Pole (1773). But, like his predecessor Hudson, he reached no farther than the northern extremity of Spitzbergen, where his vessel, surrounded by mighty ice-blocks, would have perished but for a timely change of wind. This repulse damped for a time the spirit of discovery; but hope revived again when it became known that Scoresby, on a whaling expedition in the Greenland seas (1806), had attained 81° N. lat. and thus approached the Pole to within 540 miles. No one before him had ever reached so far to the north, and an open sea tempted him mightily to proceed, but as the object of his voyage was strictly commercial, and he himself answerable to the owners of his vessel, Scoresby felt obliged to sacrifice his inclinations to his duty and to steer again to the south.

During the continental war, England indeed had little leisure to prosecute discoveries in the Arctic Ocean; but not long after the conclusion of peace (1818) two expeditions were sent out for that purpose.

Captain Buchan, with the ships "Dorothea" and "Trent," sailed with instructions to proceed in a direction as due north as might be practicable through the Spitzbergen Sea; but, having after much difficulty gained lat. 80° 34′ north in that polar archipelago, he was obliged speedily to withdraw and try his fortune off the western edge of the pack. Here however a tremendous gale, threatening every moment to crush the ships between the large ice-blocks heaving and sinking in the roaring billows, induced the bold experiment of dashing right into the body of

the ice; a practice which has been resorted to by whalers in extreme cases, as their only chance of escaping destruction.

"While we were yet a few fathoms from the ice," says Admiral Beechey, the eloquent eye-witness and narrator of the dreadful scene, "we searched with much anxiety for a place that was more open than the general line of the pack, but in vain; all parts appeared to be equally impenetrable, and to present one unbroken line of furious breakers, in which immense pieces of ice were heaving and subsiding with the waves.

"No language, I am convinced, can convey an adequate idea of the terrific grandeur of the effect now produced by the collision of the ice and the tempestuous ocean. The sea violently agitated, and rolling its mountainous waves against an opposing body, is at all times a sublime and awful sight; but when, in addition, it encounters immense masses, which it has set in motion with a violence equal to its own, its effect is prodigiously increased. At one moment it bursts upon these icy fragments, and buries them many feet beneath its wave, and the next, as the buoyancy of the depressed body struggles for reascendency, the water rushes in foaming cataracts over its edges; whilst every individual mass, rocking and labouring in its bed, grinds against and contends with its opponent until one is either split with the shock or upheaved upon the surface of the other. Nor is this collision confined to one particular spot, it is going on as far as the sight can reach; and when, from this convulsive scene below, the eye is turned to the extraordinary appearance of the blink in the sky above, where the unnatural clearness of a calm and silvery atmosphere presents itself bounded by a dark hard line of stormy clouds, such as at this moment lowered over our masts, as if to mark the confines within which the efforts of man would be of no avail, the reader may imagine the sensation of awe which must accompany that of grandeur in the mind of the beholder.

"At this instant, when we were about to put the strength of our little vessel in competition with that of the great icy continent, and when it seemed almost presumption to reckon on the possibility of her surviving the unequal conflict, it was gratifying in the extreme to observe in all our crew the greatest calmness and resolution. If ever the fortitude of seamen was fairly tried, it was on this occasion; and I will not conceal the pride I

felt in witnessing the bold and decisive tone in which the orders were issued by the commander of our little vessel (the since so far-famed and lamented Franklin), and the promptitude and steadiness with which they were executed by the crew.

"We were now so near the scene of danger as to render necessary the immediate execution of our plan, and in an instant the labouring vessel flew before the gale. Each person instinctively secured his own hold and with his eyes fixed upon the masts, awaited in breathless anxiety the moment of concussion. It soon arrrived; the brig, cutting her way through the light ice, came in violent contact with the main body. In an instant we all lost our footing, the masts bent with the impetus, and the cracking timbers from below bespoke a pressure which was calculated to awaken our serious apprehensions. The vessel staggered under the shock, and for a moment seemed to recoil; but the next wave, curling up under her counter, drove her about her own length within the margin of the ice, where she gave one roll and was immediately thrown broadside to the wind by the succeeding wave. This unfortunate occurrence prevented the vessel from penetrating sufficiently far into the ice to escape the effect of the gale, and placed her in a situation where she was assailed on all sides by battering rams, if I may use the expression, every one of which contested the small space, which she occupied, and dealt such unrelenting blows that there appeared to be scarcely any possibility of saving her from foundering. Literally tossed from piece to piece, we had nothing left but patiently to abide the issue, for we could scarcely keep our feet, much less render any assistance to the vessel. The motion indeed was so great, that the ship's bell, which in the heaviest gale of wind had never struck of itself, now tolled so continually that it was ordered to be muffled, for the purpose of escaping the unpleasant association it was calculated to produce."

By setting more head-sail, though at the risk of the masts, already tottering with the pressure of that which was spread, the vessels, splitting the ice and thus effecting a passage between the pieces, were at length released from their perilous situation, but the "Dorothea" was found to be completely disabled. A short time at Fairhaven in Spitzbergen was spent in necessary repairs, and even then she was unfit for any farther service than the

voyage to England. Franklin volunteered to prosecute the enterprise with the "Trent" alone, but the Admiralty Orders opposed such a proceeding, and the vessels returned home in company.

Meanwhile Captain John Ross, with the "Isabella" and "Alexander," had proceeded to Baffin's Bay, but instead of exploring Smith's, Jones's, and Lancaster Sounds, which recent voyages have proved to be each and all grand open channels to the Polar Sea, he contented himself with Baffin's assertion that they were enclosed by land, and, after having thus fruitlessly accomplished the circuit of the bay, returned to England.

With Parry's first expedition, which took place in the following year (1819), the epoch of modern discoveries in the Arctic Ocean, may properly be said to begin. Sailing right through Lancaster Sound, he discovered Prince Regent Inlet, Wellington Channel, and Melville Island. Willingly would he have proceeded farther to the west, but the ice was now rapidly gathering, the vessels were soon beset, and, after getting free with great difficulty, Parry was only too glad to turn back, and settle down in Winter Harbour. It was no easy task to attain this dreary port, as a canal two miles and a third in length had first to be cut through solid ice of seven inches average thickness, yet such was the energy of that splendid expedition, that the Herculean labour was accomplished in three days. The two vessels were immediately put in winter trim, the decks housed over, heating apparatus arranged, and everything done to make the ten months' imprisonment in those Arctic solitudes as comfortable as possible.

It was not before the 1st of August that the ships were able to leave Winter Harbour, when Parry once more stood boldly for the west, but no amount of skill or patience could penetrate the obstinate masses of ice, or insure the safety of the vessels under the repeated shocks they sustained. Finding the barriers absolutely invincible he gave way, and, steering homeward, reached London on Nov. 3, 1820, where, as may well be imagined, his reception was most enthusiastic and cordial.

While this wonderful voyage was performing, Franklin, Richardson, and Back, with two English sailors and a troop of Canadians and Indians, were penetrating by land to the mouth of the Coppermine River, whence they intended to make a

boat-voyage of discovery along the coasts of the Icy Ocean. An idea of the difficulties of this undertaking may be formed, when I mention that the travellers started from Fort York, in Hudson's Bay, on the 30th of August, 1819, and after a voyage of 700 miles up the Saskatchewan, reached Fort Cumberland, where they spent the first winter. The next found them 700 miles further on their journey, established during the extreme cold at Fort Enterprise. During the summer of 1821 they accomplished the remaining 334 miles, and on the 21st of July commenced their exploration of the Polar Sea in two birch-bark canoes. In these frail shallops they skirted the desolate coast of the American continent, 555 miles to the east of the Coppermine, as far as Point Turnagain, when the rapid decrease of their provisions and the shattered state of the canoes imperatively compelled their return. And now began a dreadful land-journey of two months, accompanied by all the horrors of famine. A lichen, called by the Canadians *tripe de roche* (rock-tripe), afforded them for some time a wretched subsistence, and, that failing, they were glad to satisfy their hunger with scraps of roasted leather or burnt bones, from prey which the wolves might have abandoned. On reaching the Coppermine a raft had to be framed, a task accomplished with the utmost difficulty by the exhausted party. One or two of the Canadians had already fallen behind, and never rejoined their comrades, and now three or four sank down, and could proceed no farther. Back, with the most vigorous of the men, had already pushed on to send help from Fort Enterprise; and Richardson, Hood, and Hepburn volunteered to remain with the disabled men, near a supply of the rock-tripe, while Franklin pursued his journey with the others capable of bearing him company. On reaching Fort Enterprise this last party found that wretched tenement completely deserted, and a note from Back stating that he had gone in pursuit of the Indians. Some cast-off deer-skins and a heap of bones, provisions worthy of the place, sustained their flickering life-flame, and after eighteen miserable days, they were joined in their dreary quarters by Richardson and Hepburn, the sole survivors of *their* party. At length, when on the point of sinking under their sufferings, three Indians sent by Back brought them timely succour. After a while they were

able to join this valuable friend, and the following year brought them safely back to England.

I pass over Parry's second and third voyages, undertaken in the years 1821 and 1824, which were consumed in fruitless endeavours to penetrate westward; the first through some unknown channel to the north of Hudson's Bay, the second through Prince Regent's Inlet; but his last attempt to reach the North Pole, by boat and sledge-travelling over the ice, is of too novel and daring a character to remain unnoticed. His hopes of success were founded on Scoresby's descriptions, who had seen ice-fields so free from either fissure or hummock, that, had they not been covered with snow, a coach might have been driven many leagues over them in a direct line, without obstruction or danger; but when Parry reached the ice-fields to the north of Spitzbergen he found them of a very different nature, composed of loose rugged masses, which rendered travelling over them extremely irksome and slow.

The strong flat-bottomed boats—amphibious constructions, half sledge, half canoe,—expressly built for an amphibious journey over a region where solid ice was expected to alternate with pools of water, had thus frequently to be unloaded, in order to be raised over the intervening blocks or mounds, and repeated journeys backward and forward over the same ground were the necessary consequences. In some places the ice took the form of sharp pointed crystals, which cut the boots like penknives; in others, sixteen or eighteen inches of soft snow made the work of boat-dragging both fatiguing and tedious. Sometimes the men were obliged, in dragging the boats, to crawl on all-fours, to make any progress at all, and one day, when heavy rain melted the surface of the ice, four hours of vigorous effort accomplished only half a mile.

Yet in spite of all these obstacles they toiled cheerfully on and on, until at length the discovery was made, that while they were apparently advancing towards the Pole, the ice-field on which they journeyed was moving to the south, and thus rendering all their exertions fruitless. Yet though disappointed in his great hope of planting his country's standard on that unattainable goal, Parry had the glory of reaching the highest latitude (82° 45) ever attained by man.

Before this adventurous voyage, Franklin, Richardson, and

Back, forgetful of their long life and death struggle with famine (1819), had once more (1825) with heroic perseverance bent their steps to the north. This time they chose the mouths of the Mackenzie for the starting-point of their discoveries, and having separated into two parties, proceeded to the east and west, and explored 4000 miles of unknown coast.

In 1829 Captain John Ross, having for a long time vainly solicited government to send him out once more on an Arctic expedition, was enabled by the munificence of a private individual, Mr. Felix Booth, to accomplish his wishes, and to purchase a small steamer, to which the rather presumptuous name of "Victory" was given. The selection of the vessel was no doubt unlucky enough; for can anything be conceived more unpractical than paddle-boxes among ice-blocks; but, to make amends for this error, the veteran commander was fortunate in being accompanied by his illustrious nephew, James Ross, who with every quality of the seaman united the ardour and knowledge of the most zealous naturalist.

He it was who discovered the peninsula which in compliment to the patron of the expedition was named Boothia Felix; to him also we owe the discovery of the Magnetic Pole; but the voyage is far less remarkable for these after all not very important successes, than for its unexampled protraction during a space of five years.

The first season had a fortunate termination. On the 10th of August, 1829, the "Victory" attained Prince Regent's Inlet, and reached on the 13th the spot where Parry on his third voyage had been obliged to abandon the "Fury." Of the ship itself no traces remained; but the provisions which had providently been stored up on land were found untouched. The solid tin boxes had effectually preserved them from the voracity of the white bears; and the flour, bread, wine, rum, and sugar were found as good after four years, as on the day when the expedition started.

It was to this discovery, to this "manna in the wilderness," that Ross owed his subsequent preservation; for how else could he have passed four winters in the Arctic waste? Never was the hand of Providence more distinctly visible than here.

On the 15th of August Cape Garry was attained, the most southern point of the inlet which Parry had reached on his third voyage. Fogs and drift-ice considerably retarded the progress

of the expedition; but Ross, though slowly, moved on, so that about the middle of September the map of the northern regions was enriched by some 500 miles of newly discovered coast. But now winter broke in with all its Arctic severity, and the "Victory" was obliged to seek refuge in Felix Harbour, where the useless steam-engine was thrown overboard as a nuisance, and the usual preparations made for spending the cold season as agreeably as possible.

The following spring, from the 17th of May to the 13th of June, was employed by James Ross on a sledge journey, which led to the discovery of King William's Sound and King William's Land; and during which that courageous mariner penetrated so far to the west, that he had only ten days' provisions, scantily measured out, for a return voyage of 200 miles through an empty wilderness.

After an imprisonment of full twelve months the "Victory" was set free on the 17th of September, 1830, and proceeded once more on her discoveries. But the period of her liberty was short indeed, short like that of revolted slaves between two despotisms; for, after advancing three miles in one continual battle against the currents and the drift-ice, she again froze fast on the 27th of the same month.

In the following spring we again see the indefatigable James Ross, ever active in the cause of science, extending the circle of his excursions and planting the British flag upon the site of the Northern Magnetic Pole, which, however, is not invariably fixed to one spot, as was then believed, but moves from place to place within the glacial zone.

On the 28th of August, 1831, the "Victory," after a second imprisonment of eleven months, was warped into open water, and, after having spent a whole month to advance *four* English miles, was again enclosed by the ice on the 27th of September.

But seven miles in two long years! According to this measure, there was but little hope indeed of ever seeing Old England again: the only chance left was to abandon the vessel, and endeavour by means of the boats left among the "Fury's" stores to reach Baffin's Bay, and get a homeward passage in some whaler. Accordingly the colours were nailed to the mast-head of the "Victory," and then officers and crew took leave of the ill-fated little vessel, on the 23rd of April, 1832. Captain Ross was deeply

moved on this occasion; for, after having served forty-two years in thirty-five different ships, this was the first he had ever been obliged to abandon as a wreck.

Provisions and boats had now to be transported over long tracts of rugged ice, and as their great weight rendered it impossible to carry all at once, the same ground had to be traversed several times. Terrific snow storms retarded the progress of the wanderers, and invincible obstacles forced them to make long circuits. Thus it happened that during the first month of their pilgrimage through the wilderness, although they had travelled 329 miles, they only gained thirty in a direct line.

On the 9th of June, James Ross, the leading spirit of the expedition, accompanied by two men and with a fortnight's provisions, left the main body to ascertain the state of the boats and supplies at Fury Beach. Returning, they met their comrades on the 25th of June, and gratified them with the intelligence, that, though they had found three of the boats washed away, enough still remained for their purpose, and that all the provisions were in good condition.

On the 1st of July the whole party arrived at Fury Beach, whence, after having repaired the weather-worn boats, they set out again on the 1st of August, and, after much buffeting among the ice in their frail shallops, reached the mouth of the inlet by the end of the month. But here they were doomed to disappointment; for, after several fruitless attempts to run along Barrow's Strait, the obstructions from the ice obliged them to haul the boats on shore and pitch their tents.

Barrow's Strait was found from repeated surveys to be one impenetrable mass of ice. After lingering here till the third week in September, it was unanimously agreed that their only resource was to fall back again on the stores at Fury Beach, and spend their fourth winter in that dreary solitude. Here they sheltered their canvass tent with a wall of snow, and setting up an extra stove made themselves tolerably comfortable until the increasing severity of the winter, and the rigour of the cold, added to the tempestuous weather, made them perfect prisoners, and sorely tried their patience. Scurvy now began to appear, and several of the men fell victims to the scourge. At the same time cares for the future darkened the gloom of their situation, for, if they

were not liberated in the ensuing summer, their diminishing food gave them but little hope of surviving another year.

It may be imagined how anxiously the aspect of the sea was watched during the ensuing summer, and with what beating hearts they at length embarked on the 15th of August. The spot which the year before they had attained after the most strenuous exertions was soon passed, and slowly winding their way through the ice-blocks with which the inlet was encumbered, they now saw the wide expanse of Barrow's Strait open before them. With spirits invigorated by hope they push on, alternately rowing and sailing, and on the night of the 25th rest in a good harbour on the eastern shore of Navy Board Inlet. "A ship in sight!" is the joyful sound that awakens them early on the following morning; and never have men more hurriedly and energetically set out, never have oars been more indefatigably plied. But the elements are against them, calms and currents conspire against their hopes, and to their inexpressible disappointment the ship disappears in the distant haze.

But after a few hours of suspense the sight of another vessel lying to in a calm relieves their despair. This time their exertions are crowned with success; and, wonderful! the vessel which receives them on board is the same "Isabella" in which Ross made his first voyage to these seas.

They told him of his own death, and could hardly be persuaded that it was really he and his party who now stood before them. But when all doubts were cleared away, you should have heard their thrice-repeated thundering hurrahs!

The scene that now followed cannot better be told than in Ross's own words:—

"Every man was hungry, and was to be fed; all were ragged, and were to be clothed; there was not one to whom washing was not indispensable; nor one whom his beard did not deprive of all human semblance. All, everything, too was to be done at once. It was washing, dressing, shaving, eating, all intermingled; it was all the materials of each jumbled together; while in the midst of all there were interminable questions to be asked and answered on both sides; the adventures of the "Victory," our own escapes, the politics of England, and the news, which was now four years old.

"But all subsided into peace at last. The sick were accom-

modated, the seamen disposed of, and all was done for us which care and kindness could perform.

"Night at length brought quiet and serious thoughts; and I trust there was not a man among us who did not then express, where it was due, his gratitude for that interposition which had raised us all from a despair which none could now forget, and had brought us from the very borders of a most distant grave to life and friends and civilisation. Long accustomed, however, to a cold bed on the hard snow or the bare rock, few could sleep amid the comfort of our accommodations. I was myself compelled to leave the bed which had been kindly assigned me, and take my abode in a chair for the night, nor did it fare much better with the rest. It was for time to reconcile us to this sudden and violent change, to break through what had become habit, and to inure us once more to the usages of our former days."

I have no time to relate how Ross was received in England, and what honours were heaped upon him; honours conferred with all the better grace that the nation had not forgotten him during his long-protracted absence, and had no cause to blush for culpable neglect. For Britain has ever considered it her duty to help and assist the men who venture their lives in the cause of science and for the advancement of her glory; nor will she allow the officer who carries her standard into unknown lands, and there falls a victim to nature or to man, to perish without feeling his last moments gladdened by the conviction, that, however distant his grave, the eye of his country rests upon him.

Thus when Back, that noble Paladin of Arctic research, volunteered to lead a relief expedition in quest of Ross, £4000 were immediately raised by public subscription to defray the expenses of the undertaking. While deep in the American wilds Back was gratified with the intelligence that the object of his search had safely arrived in England, but, instead of returning home, the indefatigable explorer resolved to trace the unknown course of the Thlu-it-scho, or Great Fish River, down to the distant outlet where it pours its waters into the polar seas. It would take a volume to recount his adventures in this wonderful expedition, the numberless falls, cascades, and rapids that obstructed his progress; the storms and snow-drifts that vainly

conspired to repel him; the horrors of that iron-ribbed desert, without a single tree on the whole line of his passage; and how heroically he persevered to the very last, and added Back's River, as the Thlu-it-scho has most deservedly been called, to the geographical conquests of which England may well be proud.

The present is not a detailed account of Arctic discovery, a complete historical narrative of how step by step those dreary regions, the refuse of the earth, have grown into distinctness on the map; so passing over Simpson's wonderful boat-voyage along the northern shores of America, which led to the discovery of 1600 miles of coast (1837-1839), and Rae's important researches on Melville Peninsula (1846, 1847), I proceed to the last expedition of Sir John Franklin. We all know how the veteran seaman left England in the sixtieth year of his age, once more to try the north-western passage; how since his last despatches, dated from the Whalefish Islands, Baffin's Bay, July 12th, 1845, months and months, and then years and years, elapsed without bringing any tidings of his fate; how Collinson and M'Clure, Penny and Inglefield, Kane and Bellot, and so many other worthies, went out to search for the "Erebus" and "Terror," and how in spite of all their efforts mystery still overhung the ill-fated expedition, until M'Clintock raised the veil and informed us how miserably most of the gallant seamen perished in those dreary wastes, but how their commander had been spared the pangs of protracted suffering, and gone to his eternal rest even before his country began to feel concerned about his loss.

The search for Franklin is a page in history of which a nation may well be proud, more noble than a hundred battles and grander than the conquest of an empire. These are no blood-stained laurels, but palms of glory gained by matchless energy and perseverance over the horrors of a nature inimical to man, a theme which some future Homer will delight to sing. Had Franklin been ever so successful, he could not possibly have achieved so much for Arctic discovery as his loss gave rise to; for to the disasters of his voyage we owe the knowledge of all the coasts of that intricate conglomeration of islands which faces the Pole, and of the channels, which opening far to the north, lead to its profoundest, and seemingly impenetrable depths. All these discoveries are of little commercial value, it is true,

for no trading vessel will ever plough those desert seas; but it is no small advantage to a nation to have to register such pages in her annals, and to leave them as a legacy and an example to future generations.

The series of modern South Polar expeditions was opened in 1819 by Smith's casual discovery of New South Shetland. Soon afterwards a Russian expedition under Lazareff and Bellinghausen discovered (January, 1821), in 69° 3′ south lat., the islands Paul the First and Alexander, the most southern lands that had ever been visited by man.

The year after, Captain Weddell, a sealer, penetrated into the icy sea as far as 74° 15′ south lat. three degrees nearer to the pole than had been attained by the indomitable perseverance of Cook. Swarms of petrels animated the sea, and no ice impeded his progress, but as the season was far advanced, and Weddell apprehended the dangers of the return voyage, he steered again to the north. In 1831 Biscoe discovered Enderby Land, and soon afterwards Graham's Land, to which the gratitude of geographers has since given the discoverer's name.

Then follows Balleny who in 1839 revealed the existence of the group of islands called after him, and of Sabrina Land (69° south lat.).

About the same time three considerable expeditions appear in the southern seas, sent out by France, the United States, and England.

Dumont D'Urville discovered *Terre Louis Philippe* (63° 30′ south lat.) in February, 1838, and *Terre Adêlie* (66° 67′ south lat.) on the 21st of January, 1840.

Almost on the same day, Wilkes, the commander of the United States exploring expedition reached a coast which he followed for a length of 1500 miles, and which has been called Wilkes' Land, to commemorate the discoverer's name. But of all the explorers of the southern frozen ocean, the palm unquestionably belongs to Sir James Ross, who penetrated farther towards the Pole than any other navigator before or after, and followed up to 79° south lat. a steep coast, whose enormous glaciers stretched far out into the sea. In 77° 5′ south lat. he witnessed a magnificent eruption of Mount Erebus, the Etna of the extreme south. The enormous columns of flame and smoke rising two thousand feet above the mouth of the crater, which is ele-

vated 12,000 feet above the level of the sea, combined, with the snow-white mountain-chain and the deep blue ocean, to form a scene, the magnificence of which seemed to be enhanced by the reflection that no human eye had ever witnessed its beauty, as most likely none will ever witness it again. As all the efforts of the gallant leader to penetrate still farther to the south were baffled by a mighty ice-barrier, forming an uninterrupted mural precipice for the length of several hundred miles, he yielded to the invincible obstacles of nature, and returned to more genial climes. It is worthy of notice, that Sir James Clark Ross had accompanied Parry on his sledge-expedition to the North Pole, and thus acquired the unique distinction of having approached *both* poles nearer than any other man.

Whether the lands discovered by Wilkes, D'Urville, Biscoe, Balleny, and Ross form a continuous continent, or belong to a large group of islands behind which an open sea extends to the very Pole, is a question which most likely will never be solved, as its determination can never be of the least use to mankind.

The numerous scientific voyages of circumnavigation achieved during the course of the present century are far more important, with regard to the welfare and progress of humanity, than the researches which have been made in the icy wildernesses of the north and south. New lands and isles of great extent have indeed not been discovered by these expeditions, but they have contributed not less largely to the advancement of geography and the natural sciences.

The wonders of oceanic life have first been shown in a more distinct light by the labours of Chamisso, Meyen, Lesson, Darwin, Gray, Hooker, Robinson, Dana, &c., who accompanied Kotzebue, Freycinet, Fitzroy, Ross, &c., on their world-encircling course; and numerous coasts and groups of islands, situated in the remotest seas, and formerly only superficially known, have been accurately measured and traced on the map by the distinguished hydrographers who took part in those far-famed voyages.

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INDEX

INDEX.

AAR glacier, formation and dissolution of the, 75
Acalephæ, 348. *See* Jelly-fishes
Acephala, their organisation, 299
— their food, 305
— their enemies, 305, 306
Acorn-shell, the, 244
Actiniæ, 361
Actinozoa, 363
Adriatic, depth of the, 8
— tides of the, 43
Africa, length of coast-line of, 4
— circumnavigated by the Phœnicians, 444
— Hanno's discoveries on the west coast of, 444
Agar-agar, or artificial edible birds'-nests of Java, 402
Agricola, Julius, sails round Scotland, 422
Air-bladder of fishes, 189
Air-currents. *See* Winds
Albatross, 163
Albion, New, discovery of, 467
Alcyonarians, 363
Alexander the Great, maritime discoveries resulting from the conquests of, 447
Alexandria, the Pharus or lighthouse of, 89
Algæ, 390
— changes produced by, in the colour of the sea, 19
— Russian official collecting, 392
Alligators, 172
Amalfi, maritime trade of, 449
— decline of, 449
Amazon river, tides of the, 43
— — quantity of water which it pours into the ocean, 75
— — discovery of the river, 460
America, length of coast-line of, 4
— salmon of Russian America, 221
— discovery of, by Columbus, 457
— account of early navigation along the shores of, 457
Amerigo Vespucci, his discoveries, 460
Ammodyte, or launce, 230
Ammonites, 437
Amœbæ, 379
— simplicity of their structure, 380
Anabas of the dry tanks, 193
Anchovy, 214
Angler, or sea-devil, 203
Annelides, marine, 262
— general remarks on the, 262
— their beauty, 263
— their food, 264
— their enemies, 265
— tubicolé, 266
Anson, Commodore, his maritime discoveries, 483
Aphrodita, or sea-mouse, 264
Arab commerce and maritime discovery, 452
Arctic discovery, 474, 496
— winter passed by Barentz, 478
Argand, his improvement in marine illumination, 90
Argonaut, 280
Argus, Scotch or Shetland, 333
Ascidia mammillata, 322
Asia, length of coast-line of, 4
Asteriæ, 335
Astræa, 373
Atlantic Ocean, depth of the, according to Maury, 7
— — temperature of the, 14
— — fury of the Atlantic surge, 28, 29
— — enormous fucus banks, or floating meadows of the, 397
Atolls, or lagoon islands, 374
Auburn, site of the village of, 29
Auks, 151, 168
Australia, length of coast-line of, 4
— discoveries in, 480, 486
Avosets, 143, 144, 146
Azores, discovery of the, 456

BACK'S arctic voyages, 507
Baffin, his maritime discoveries, 483
Baffin's Bay, discovery of, 483

Balani, 244
Balanus ŏvularis, 244
— balanoides, 244
Balboa, Vasco Nuñez de, sketch of him and his discoveries, 464
Baleen of the whale, 98
Balleny, his discoveries, 509
Baltic, depth of the, 8
Band-worm, the great, 264
Barentz, William, his maritime discoveries, 476
Barnacles, 244
— their attacks on the whale, 17
Barnacle goose, 146
Barrow's Straits, discovery of, 505
Basaltic pillars of Fingal's Cave, 46
Bassora, foundation of the town of, 452
Bastidas, Roderigo de, his maritime discoveries, 461
Beachy Head, 5
Bear, white, said to attack the whale, 100
— organisation of the polar bear, 10
— attacks Barentz's men, 478
Bear Islands, discovery of, 477
Behring, his maritime discoveries and death, 484
Belemnites, 437
Bellrock lighthouse, 28, 86
— — height of the waves at the, 28
— — in the storm of 1807, 29
Benin, discovery of, 456
Bermudas, depth of the sea near the, 7
Bird Island, discovery of, 490
Bird's-foot sea-star, 335
Birds'-nests, edible, of Java, 399
— mode of gathering them, 399
— agar-agar, or artificial birds'-nests, 402
Birds of passage, 171
Birkenhead, the Great Float at, 91
Biscoe, his discoveries, 509
Bivalves, or acephalous mollusca. *See* Acephala
Black-skimmer, or cut-water, the, 144
Blocks, erratic, of Greenland and Spitzbergen, 76
Bojador, Cape, doubling of, for the first time, 455
Bonito, the, 223, 224
Booth, Mr. Felix, 503
Boothia Felix, discovery of, 503
Borda, his improvements in marine illumination, 90
Borer, the, 231
Botallack, submarine mine, 91
Botrylli, 324
Bougainville, his maritime discoveries, 483
Boundaries of the ocean. *See* Limits of the ocean
Brachiopods, 315
Brazils, discovery of the, 460
Breakwater of Cherbourg, 90
— of Plymouth, 90
— moles of Portland, Holyhead, and Alderney, 90
Bream, sea, 415
Bristol Channel, high tides of the, 38
— — marine fauna, 414
Britannia Tubular Bridge, 91
Bryozoa, 316
Buchan, Captain, his arctic discoveries, 497
Buffadero, the marine cave of the, 52
Bullhead, river, its parental affection, 195
Burgomaster-bird, 159
Butthorn, the, 335
Byron, Commodore, his maritime discoveries, 483

CABOT, John and Sebastian, their discoveries, 459
Cachalot, or sperm-whale, its organisation, 102–104
— its food, 104
Ca'ing whale, the, 115
Calamary, 272
Caledonia, New, discovery of, 490
California, discovery of, 472
Callao, colour of the sea near, 20
Calling crabs, 250, 251
Calms, or doldrums, causes of, 67
Calycophoridæ, 352
Canada acquired by France, 461
Canary Islands probably known to the Phœnicians, 444
Cano, Sebastian el, first performs the circumnavigation of the globe, 469
Cape de Verd Islands, depth of the sea near the, 7
Capelins, 162
Capri, 'azure cave' at, 18, 49
Carcinas mænas, metamorphosis of, 258
Caribbean Sea, crystalline clearness of the, 21
Carinaria, 287
Carrigeen (Chondrus crispus), 399
Carteret, his maritime discoveries, 483
Cartier, Jacques, voyages of, 461
Caryophyllia, 370
Cat-fish, or sea-wolf, 415
Catalonians, their maritime discoveries, 452
Caves, marine, 45
— Fingal's Cave, 45–48
— azure cave of Capri, 18, 49
— the Antro di Nettuno, 49
— the Cave of Hunga, 49–51
— cave of the Skerries, 51

Caves, marine—*continued.*
— the Souffleur, or Blower, 52
— the Buffadero, 53
Caviar, 217
Cellulariæ, 319
Cephalopods, their organisation, 271
— their locomotion, 274
— their food, 277
— their enemies, 277
— their great size in some cases, 379
— the Norwegian kraken, 279
— the argonaut, 280
— the nautilus, 281
— the cephalopods of the primitive ocean, 282
Cessart, De, his breakwater at Cherbourg, 90
Cetaceans, general remarks on the organisation of the, 95
— food of whales, 98
— their enemies, 99
— large Greenland whale, 101
— the rorqual, or fin-back, 101
— the antarctic smooth-back, 102
— sperm-whale, 102
— the narwhal, or unicorn-fish, 106
— the dolphin, 107
— the porpoise, 108
— the grampus, 108
— history of the whale-fishery, 109
— the ca'ing whale, 115
Cetochilus australis, banks of the, in the Pacific, 21
Ceylon, or Taprobane, discovery of, 447
Chætodon rostratus, 203
Chancellor's discovery of the White Sea, 474
— his death, 475
Charybdis, vortex of, 41
Chelura tenebrans, 247
Chelyosoma, 323
Chepstow, high tides at, 38
Cherbourg, breakwater of, 90
Chili, upheaving of the coast of, 10
Chincha Islands, statistics of the guano trade of the, 169
Chiton squamosa, 285
Chlorospermæ, or green sea-weeds, 391
Chondrus crispus, or carrigeen, 399
Circumnavigation of the globe first performed by Sebastian el Cano, 460
Clavellina producta, 322
Climate, influence of the Gulf Stream on that of the west European coasts, 51
— variety of climates in similar latitudes, 52
— Peruvian cold stream, 53
— Japanese stream, 54
— influence of forests on climates, 78
— power of man over climate, 78
Climbing fishes, 193
Clio borealis, 298
Clouds, formation of, 71, 72
Coast-line of the sea, length of, 4
Coasts, different formation of, 5
— destructive power of the sea on all, 29
Cockle, the, 303, 306
Cocoa-nut crab of the East Indies, 254
Cod, the, 415
— curing the cod, 216
— cod-liver oil, 216
Cœlenterata, 345, 357
Colæus of Samos, his maritime discoveries, 446
Colour of the sea, 17
— the azure cave at Capri, 18
— changes produced by algæ and sea-worms, 19
Columbus, his discovery of America, 457
Compass, mariner's, invention of the, 451
Composition of sea-water, 12
Cone-shell, orange, 288
Conger-eels, 222
Congo, discovery of, 456
Constructions, marine, 80–91
Cook, Captain, his voyages and discoveries, 485
— his first voyage, 486
— discovery of the Society Islands, 486
— — of the east coast of New Holland, 486
— his second voyage, and discoveries, 492
— his third voyage, 491
— his death, 462
Cook's Strait, discovery of, 486
Conochilus volvox, 268
Coral, spotted, of the Indian Ocean, 21
Coral, 366
— deep sea, 367
— fishing of the Mediterranean, 367
Coral-reefs, 374
— barrier-reef of Australia, 374
— how they become habitable for man, 375, 376
Coralline zone, 413
Cordova, his discoveries, 491
Cormorants, 154, 155
Cortereal, Gaspar, his maritime discoveries, 460
Cortereal, John Vaez, his discoveries, 458
Cortereal, Miguel, 461
Cortes, his conquest of Mexico, 461
Coryniadæ, 358
Crabs, 246
— legs of crabs, 251
— larvæ of crabs, 258
Cross-fish, the common, 334
Crustacea, by what are they distinguished from the insects and spiders? 243
— their respiratory organs, 244

Ctenophora, 358
Cuba discovered, 459
— circumnavigated for the first time, 461
Curlew, the, 143
Currents, ocean, 54
— causes of, 54, 55
— the equatorial stream, 56
— the Gulf Stream, 57
— influence of the Gulf Stream, 60
— the cold Peruvian stream, 62
— the Japanese stream, 63
— beneficial influence of the ocean currents, 64
Cushion star-fishes, 335
Cuttle-fish, 275
— ova of the, 278
Cuvier's classification of fishes, 188
Cyclobranchiata, 285
Cyclones, causes of, 68
Cymospiras, 266

DAMPIER, his maritime discoveries, 483
Darien, Gulf of, discovered, 461
Darwin's theory of the formation of lagoon islands, 375
Davis, John, his maritime discoveries, 476
Depth of the sea, 6
— of the Atlantic, according to Maury, 7
— American mode of sounding in deep water, 6
— telegraphic plateau between Newfoundland and Ireland, 7
— measurement of depth by the rapidity of tide-wave, 8
Dew, formation of, 68
Diatomaceæ, 402
— their importance in reference to the existence of animal life in high latitudes, 403
Diaz, Bartholomew, his discovery of the Cape of Good Hope, 476
Diazona violacea, 324
Diodons, 178
Diogenes hermit-crab, 254
Diphyes, 352
Discovery, maritime, progress of, 441. *See* Maritime Discovery
Diu, Portuguese settlement of, 462
Divers, 150
Docks of London and Liverpool, 91
Dogfish, 200
Dolphins, 107
Donax, 301
Dory, 242
Dragon-weever, 204
Drake, Sir Francis, his discoveries, 473
Duck family, 146
Dugong, 117
— skeleton of the, 118
— female dugong of Ceylon, 119
Dunes, formation of, 5
Dunwich, destruction of the coast at, 30
D'Urville, Dumont, his discoveries, 509
Dusky Bay, discovery of, 487
Dutch, their attempts to discover a North-West passage to India, 474, 476

EARTH-RIND, the giant book of the, 432
— formation of a solid earth-crust by cooling, 432
Echinus, or sea-urchin, 337
— mammillated, 338
— edible, 338
— dental apparatus of sea-urchins, 339
Eddystone lighthouse, the, 81
— Winstanley's structure, 81
— Rudyerd's, 82
— Smeaton's, 83
Edward's Island, Prince, discovery of, 491
— Land, 415
Eel, the common, 225
— conger, 228
— the murry, or muræna, 229
Eendragt's Land, discovery of, 480
Eider-duck, 146
Electric eel, 202
Endeavour Strait, discovery of, 486
Enderby Land, discovery of, 509
English navigation, retrospective view of, 459
— attempts to discover the North-West passage, 474
Enteromorphæ, 391
Eolis coronata, 284
Eozoon canadense, 381 *note*
Equatorial ocean-current, 57
Equinoctial line crossed for the first time, 456
Erebus, Mount, discovery of, 509
Escharæ, 317
Espiritu Santo, discovery of the Archipelago of, 480, 490
Esquimaux in his kayak, 120
Euripus, phenomenon produced by the tides of the, 44
Europe, length of coast-line of, 4
Euryale, warted, 333
Evaporation, movement of the waters through, 65
Extent of the ocean, 1

FALKLAND ISLANDS, sea-weeds at, 396
Fan-bearer, 402, 403

Feather-star, the rosy, 330
Fernandez, Juan, his discoveries, 473
Fierasfer, 340
File-fish, 232
Fin-crab, spotted, 252
Fin-fish, or northern rorqual, 101
Fingal's Cave, 45-48
— — popular belief as to its workmanship, 48
— — Sir W. Scott's description of it, 48
Fire, sea of, 434
Fish, consumption of, in London, 237 *note*
Fish River, Great, course of, traced, 507
Fishes, general remarks on, 186
— their locomotive organs, 187
— Cuvier's classification of fishes, 188 *note*
— fins, 188
— air-bladder, 189
— skin of, 190
— beauty of tropical, 191
— gills of, 191
— circulation of the blood of, 191, 192
— climbing, 193
— parental affection of, 194
— organs of sense, 196
— offensive weapons of, 198
— numerous enemies of, 207
— luminous, 422
Flamingoes, 142
Flat-fishes, 235
Florence, its commercial grandeur, 450
Flounder, 238
Flying-fishes, 156, 205, 224
Flying-gurnard, 206
Foraminifera, 378
— their immense numbers, 378
— simplicity of their structure, 380
— various forms of Foraminifera, 381
Forbes, Professor Edward, on the four zones of marine life on the British coasts, 408
Forests, influence of, on the formation and retention of atmospherical precipitations, 76
— formation of, 77
— influence of, on climates, 78
Franklin, Sir John, his arctic voyages, 501
— his last voyage, 508
Fresnel, his improvements in marine illumination, 90
Frigate-bird, 155
Frobisher, Martin, his maritime discoveries, 475
Frog-fish, 193, 194
Fuci, 392
— fucus banks, or floating meadows, of the Atlantic 397,
Fulmar, the, 195

GADES, Phœnician town of, 444
Gaëta, maritime trade of, 451
Gama, Vasco de, doubles the Cape of Good Hope, 462
Gannet, or soland goose, 156
Gar-fish, 223
Garry, Cape, discovery of, 503
Gasteropods, 282
— respiratory apparatus, 283
— growth of their shells, 289
— mode of locomotion, 289
— their food, 294
— organs of sense, 295
— their enemies, 297
— their use to man, 296
Genoa, maritime grandeur of, 450
Geographical distribution of marine life, 405
Georgia, South, discovery of, 490
Germany, its climate at the time of the Romans and at the present time, 78
Glaciers, formation and dissolution of, 75
— the Aar glacier, 75
— of Greenland and Spitzbergen, 76
Glaucus, 283
Globe-fish, 232
Goa, Portuguese settlement of, 462
Goby, the black, 194
Goniaster, 335, 336
Good Hope, Cape of, discovery of, 457
— — first doubled, 462
Goodwin Sands, 9
Goose, sea, various kinds of, 146
Gorgonidæ, 365
Grampus, the, 108
— — anecdote of one, 109
Grass wrack (Zostera marina), 391
Great crab, 251
Grebes, the, 150
Greenland, depression of the coast of, 10
— olive colour of the water of the Greenland seas, 20
— glaciers of, 76
— whale-fishery of, 110
— discovery of, 457
Grijalva, his maritime discoveries, 461
Guano of the Chincha Islands, 169
— statistics of the trade of, 170
Guillemot, black, 165, 167
Guinea, New, discovery of, 473
Gulf Stream, the, 57, 58
— — its influence on the climate of the west European coasts, 59
Gulls, sea, 157
Gunnbjorn, his discovery of Greenland, 457
Gurnard, 414

HADDOCK, 215
Hag, glutinous, 231
Haiti discovered, 459
Halibut, 236
Hanno, the Carthaginian, his voyage, 444
Harp-shell, 288
Hartburn, site of the village of, 29
Hartog, his maritime discoveries, 480
Hassar, land journeys of the, 194
Hawaii, discovery of the island of, 492
Hebrides, New, discovery of the, 480, 490
Henry, Prince, of Portugal, his maritime discoveries, 453
Hermit-crabs, 254
Herrings, 208, 415
Herring-crab, 256
Herring-fishery, 208
— history of the, 209
— statistics of the, 210
Herring-gull, 158
Hervey's Islands, discovery of, 487
Hindostan, circumnavigation of, 447
Hippocamp, 129, 234
Hippopus, 315
Hoar-frost, causes of, 72
Hogg, James, his experiments with salmon, 219
Holland, devastations caused by storm-tides on the coast of, 35
Holland, New, discoveries of, 473
— — Cook's discoveries in, 486
Holothuriæ, 339
Homer, his picture of the breaking of the waves against the shore, 27
Hood's Island, discovery of, 489
Hooded seal of northern seas, 125
Huatulco, sea-cave of, 52, 53
Hudson, Henry, his maritime discoveries, 481
— his unfortunate end, 482
Hudson's Bay, discovery of, 481
Hump-back whales, 102
Hunga, cave of, 49–51
Hyaleæ, 298
Hyde, site of the village of, 29

IANTHINÆ, 290
Ice-bear, 100, 134
Icebergs, formation of, 76
— erratic blocks carried away by, 76
Iceland, salmon of, 220
— discovery and colonisation of, 361
Ichthyosaurus, 438
Inachus Kæmpferi of Japan, 259
India, Portuguese discovery in, 462
Indian Ocean, spotted corals in the, 21
Indus, sudden rising of the spring-tide at the mouth of the, 42
Inferobranchiata, 284
Infusoria, marine, 383
Insects, marine, 261
Isinglass, 216
Isis hippuris, 369
Ivory of the walrus, 132

JAMAICA discovered, 459
Japanese ocean-stream, the, 63
Java, gathering of edible birds'-nests on the south coast of, 399
Jelly-fishes, 345
— their anatomical structure, 345
— their size and colours, 356
— their indirect use to man, 357
— their phosphorescence, 420
— the Velella, 353
— the Portuguese man-of-war, 354
John Dory, 415

KAMTSCHATKA, salmon of, 220
Keeling Island, subsidence of the coast at, 10
Kerguelen's Land, discovery of, 491
Kilda, St., bird-catching on, 164
King-crab, 246
Kittiwake, or tarrock, the, 158
Kraken, the Norwegian, 279

LABRADOR, discovery of, 459
Ladrone Islands, discovery of the, 468
Lagoon islands, 374
— — Darwin's theory of the formation of, 375
— — how they became habitable for man, 376
Lamantins of the Atlantic Ocean, 117
Laminaria, region of the great, or tangle forests, 393
Laminariæ, 393
Lampreys, 230, 231
Land-crabs, 250
Landscapes, submarine, 21
— in the Caribbean Sea, 21
— on the coast of Sicily, 21
La Perouse, his maritime discoveries, 493
— — his fate, 493
Launces, 230
Le Maire, his maritime discoveries, 480
Lepraliæ, 318
Lessonias, of the Falkland Islands, 396
Level of the ocean, does it remain unchanged, and everywhere the same? 11
Licmophora, or fan-bearer, 402
Life, marine, geographical distribution of, 405
— dependence of all created beings upon space and time, 406

Life—*continued.*
— influences which regulate the distribution of marine life, 407
— the four bathymetrical zones of marine life on the British coasts, according to the late Professor Edward Forbes, of Edinburgh, 408
— first wakening of life in the bosom of the ocean, 435
Lighthouses, 80
— the Eddystone lighthouse, 81
— the Bellrock, or Inchcape, lighthouse, 85
— the Skerryvore lighthouse, 85–89
— the Pharus of Alexandria, 89
— progress of marine illumination, 90
Lily encrinites, 340
Limacina arctica, 298
Limits of the ocean, progressive changes in the, 9
— Goodwin Sands, 10
— alluvial deposits, 10
— upheaving of coasts, 10
— subsidence, 10
— temple of Serapis, 11
— level of the sea everywhere the same, 11
Limnoriæ, 247
Limpet, 285, 294
Limuli, or king-crabs, 246
Ling, 215, 415
Lingthorn, 335
Lithophytes, 373
Liverpool Docks, 91
Lizards of the sea, 173, 181
— serpent-lizard, 435
Lobsters, 256, 257
Loggerheaded duck or goose, 148
London Docks, 91
Long-tailed duck, 148
Lophobranchii, the, 233
Louse, whale, 101
Lucernaridæ, 350
Luminous marine animals, 418
Lump-sucker, 415

MACKEREL, 222
Macrocystis pyrifera, 393
— — Mr. Darwin's description of it at Tierra del Fuego, 393, 396
Madeira, depth of the sea near, 1
— discovery of, 505
Maelstrom, the, 41
Magellan, Ferdinand, his discoveries, 467, 468
Magellan's Straits, discovery of, 468
— — harmony of animal life in the islands of, 490
Magilus antiquus, 291
Malacca Islands, discovery of the, 462
Malo, St., high tides of, 38
Mammaria scintillans, 275
Manatee, the, 116
Mantis crab, spotted, 256
Marco Polo, his travels and discoveries, 453
Maritime discovery, progress of, 441
— discoveries of the Phœnicians, 443
— expedition of Hanno, 444
— circumnavigation of Africa, under Pharaoh Necho II., 444
— Ophir, 339
— Colæus of Samos and Pytheas of Massilia, 340
— expedition of Nearchus, 447
— circumnavigation of Hindostan, under the Ptolemies, 447
— voyages of discovery of the Romans, 453
— consequences of the fall of the Roman empire, 448
— Amalfi, 449
— Pisa, Venice, and Genoa, 449
— resumption of maritime intercourse between the Mediterranean and the Atlantic, 451
— discovery of the compass, 451
— Marco Polo, 453
— other discoveries, 453
— Prince Henry of Portugal, 454
— discovery of Porto Santo and Madeira, 455
— doubling of Cape Bojador, 455
— discovery of the Azores, 456
— the line crossed for the first time, 456
— Benin and Congo discovered, 456
— and the Cape of Good Hope, 457
— discovery of America, 457
— and of Iceland, 457
— Greenland, 457
— discoveries of John and Sebastian Cabot, 459
— retrospective view of the beginnings of English navigation, 461
— Ojeda and Amerigo Vespucci, 460
— Vincent Yañez Pinson, 460
— Cortes, 461
— Verazzani, 461
— Jacques Cartier, 461
— the Portuguese in the Indian Ocean, 462
— Balboa's discovery of the Pacific Ocean, 466
— Magellan, 467
— Sebastian el Cano, the first circumnavigator of the globe, 469
— Pizarro and Cortes, 470
— Urdaneta, 472
— Juan Fernandez, 473
— Mendoza, 473
— Drake, 473

Maritime discovery—*continued.*
— Willoughby and Chancellor, 474
— Martin Frobisher, 475
— Davis, 476
— Barentz, 476
— Quiros, 480
— Torres, 480
— Schouten, Le Maire, and others, 480
— Tasman, 480
— Henry Hudson, and his unfortunate end, 481
— Baffin, 481
— Dampier, 483
— Anson, Behring, Byron, Wallis, Carteret, and Bougainville, 483
— Cook's voyages, 485–492
— arctic discovery, 496
Marquesas de Mendoza Islands, discovery of the, 473
Mauritius, sea-cave on the, 52
Mediterranean Sea, depth of the, 8
— — height of the, 12
— — temperature of the, 14
— — colour of the, 18
— — sides of the, 43
— — Phœnician trade in the, 443
— — decline of trade in the, 33
— — resumption of maritime intercourse between the Mediterranean and the Adriatic, 449
Medusidæ, 349, 350
Melanospermeæ, or olive-coloured seaweeds, 392
Melville Island, discovery of, 500
Mendana, Alvaro, his discoveries, 473
Menezes, Don Jorge de, his discoveries, 473
Merganser, 149, 404
Mexico, discovery of the coast of, 461
— conquest of, by Cortes, 461, 472
Microscopic life of the ocean, 378
Mines, submarine, 91
Mitre shells, 288
Mollusca, 270
— general remarks on, 270
Monsoons, north-east, 68
— south-west, 68
Moon, influence of the, on the tides, 446
Mother-of-pearl, 313
Mullet, grey, 415
Murex haustellum, 291
Murry, or muræna, 229
Mussels, edible, 307
— history of, 307
— 'bouchots,' or mussel-parks, 307
Myxine, the, 231

NAPLES, maritime trade of, 449
Narwhal, or unicorn-fish, 106
Nautilus, 280
— the pearly, 281
Nearchus, voyage of, 447
Necho II., Pharaoh, of Egypt, his maritime discoveries, 444
Nelson, Horatio, pursuing a polar bear, 138
Neptune's ruffles, 318
Nereis, the, 263
Nereocystis lutkeana, the, of Norfolk Bay and Sitcha, 397
Nettuno, Antro di, 49
Newfoundland, discovery of, 459
Noctiluca miliaris, 419
Norfolk, rapid destruction of the cliffs of, 29
Norfolk Island, discovery of, 490
North Sea, depth of the, 8
— — colour of the, 18
North-West Passage, attempts of the Dutch and English to discover the, 474
Norway, treaty of commerce concluded with, 459
Nova Zembla, 476, 477
— — sufferings of Barentz and his crew during a winter at, 478
Nudibranchiata, 284
Nummulina discoidalis, 378

OAR-WEEDS, 393
Ocean, the primitive, 433
Ojeda, discoveries of, 460
Oliva hispidula, 290
Onychoteuthis, arms and tentacles of an, 274
Ophir, the, of the Phœnicians, 445
Ophiuridæ, or snake-stars, 331
Orkney Islands, whirlpools among the, 42
Ormus, taken by the Portuguese, 462
Ostend, oyster-parks of, 309
Otarian seals, 126
Oyster, 307
— account of the oyster-trade, 308
— catchers, 143
— oyster-dust, 310
— pearl, 311

PACIFIC OCEAN, depth of the, 7
— — height of the, 12
— — discovery of the, 466
— — Cook's voyages in, 492
Paguri, 254
Palliser Islands, discovery of the, 489
Palmas, Cape, colour of the sea near, 20
Palmyra, 445
Parrot-fishes, 372
Parry, Sir John, his arctic discoveries, 500
Patagonia, discovery of, 484

Pea-crab, 253
Pearl-oyster, 311
Pearls, 311, 312
Pectinibranchiata, 288
Pectunculus, 302
Pegasus, swimming, 207
Pelamid, 224
Pelamys bicolor, 183
Pelicans, 116, 154
Penguins, 142, 152
— species of, 153
Pentacrinus briareus, 330
Periwinkle, 411
Peru, visited by Pizarro, 471
— conquered by him, 472
Peruvian ocean-current, the, 62
Petrels, 160
— stormy, 162
Philippine Islands, discovery of the, 468
Philodina roseola, 269
Phœnicians, maritime discoveries of the, 443
— their progress in the arts and sciences, 445
Pholades, 304
Pholas dactylus, 301
— Pliny's accounts of its phosphorescence, 431
— striata, 302
Phosphorescence of the sea, causes of, 418
— of various marine animals, 418
Phyllosoma, 258
Physaliæ, the, 354
Physophoridæ, 353
Pilchards, 212, 415
Pilot-fish, 225
Pinnæ of the Mediterranean, 253, 304, 305
Pinson, his discoveries, 460
Pipe-fishes, 233, 234
Pisa, maritime trade of, 449
Pizarro, sketch of him and his companions, 469
Plaice, 238
Plants, marine, 390
Plectognaths, 232
Plesiosaurus, the, 438
Pleuronectidæ, or flat-fishes, 235
Pliny, his geographical knowledge, 448
Plover, the, 144
Plymouth breakwater, in the great storm of 1824, 29
Polycystina, 382, 383
Polynesia, length of coast-line of, 4
Polyps, 345
Polyzoa, 316, 320
Porcupine-fish, 232
Porpoise, 108
Portland, destructive action of the sea at, 31
Porto Santo, discovery of, 455
Portuguese man-of-war, 354
Poulp, 272, 273
Prontzchitschew, his maritime discoveries, 483
Protozoa, 378
Pteroceras, 290
Pteropods, their organisation and mode of life, 298
— the butterflies of the ocean, 299
Ptolemies, maritime discoveries of the, 447
Ptolemy, the geographer, his knowledge of the globe, 449
Ptygura melicerta, 267
Puffins, 165, 167
Purbeck, destruction of the cliffs at, 31
Pyrosoma atlantica, its phosphorescence, 420
Pyrosomes, 325
Pytheas of Massilia, his maritime discoveries, 446

QUANTITY of the waters contained within the bosom of the ocean, 8
Quiros, his maritime discoveries, 480
Quito, coast of, discovery of, 470

RACER, or rider-crab, the, 251
Rain, formation of, 72
— inequality of, 72
— its return to the sea, 73
Rays, 240
Razor-shell, 303–306
Ré, oyster-trade of, 311
Reculver, destruction of the coast at, 30
Red Sea, height of the, 12
— — red algæ of the, 20
— — Phœnician trade on the, 445
Reef-building corals, 374
Regent Inlet, Prince, discovery of, 500
Reptiles of the sea, 172
Rhodosperms, Florideæ, or red seaweeds, 398
— their habitat, 398
Richardson, Sir John, his arctic voyages, 501
Rivers, phenomena presented by the mixture of salt and fresh water in, 16
— quantities of water which rivers pour into the ocean, 75
Rock-goose, 149
Roggewein, his maritime discoveries, 483
Rome, ancient, maritime discoveries of, 448

Rorqual, northern, or fin-fish, 101
— its food, 102
Ross, Sir James, on the height of waves, 28
— — — his discoveries, 509
— — John, his arctic discoveries, 500, 503
Rotifera, the, 267
Rudyerd, Mr., his lighthouse on the Eddystone rocks, 82

SAAVEDRA, Alvaro de, his discoveries, 473
Sabrina Land, discovery of, 509
Sagittaria, discovery of the island of, 480
Sail-fluke, 239
Salangana caves in Java, 399
Salmon, 217, 324
— trade, 220
— salmon-spearing, 219
— growth of the salmon, 219
— abundance of salmon, 220
— introduced into Australia and New Zealand, 221
Salmon-leaps, 218
Salpæ, 325
— their alternating generations, 327
Salts of the sea, 12
Sand-crab, American, 252
Sand-hopper, 246
Sand-stars, 332
Sandwich Land, discovery of, 490
— Islands, discovery of, 490
Sardinia, stalactite caves of the island of, 49
Sargasso Sea, the, 397
Saurians of the past seas, 172, 438
Scari, or parrot-fishes, 372
Schouten, his maritime discoveries, 480
Scissor-bill, 144
Scoopers, 143
Scoresby, his arctic voyages, 497
Scyllæa, 283
Scythe, the, 415
Sea-anemones, 361
Sea-bear, 117, 126
Sea-birds, 128, 142
— their vast numbers, 142
Sea-cask, 142
Sea-cucumbers, 339
Sea-devil of the Pacific, 241
Sea-ear, 286, 287
Sea-elephant, 125
Sea-fox, 99
Sea-hare, 284, 295
Sea-horse, 129, 234
Sea-lemon, 284
Sea-lion, 128
Sea-mat, leaf-like, 316
Sea-mew, 157
Sea-otter, 139
— chase of the, 139
Sea-pen, 364
— its phosphorescence, 420
Sea-pie, the, 144
Sea-pinks, 391
Sea-scurfs, 318
Sea-snail, purple, 290
Sea-snakes, 183
Sea-squirts, 323
Sea-swallows, 157
Sea-urchin, 337
Sea-weeds, 391
— luminous, 423
Sea-wolf, 197
Seals and walruses, 117
— food of, 120
— statistics of seal-fishery, 121
— various kinds of, 123
Seine, sudden rising of the spring-tides at the mouth of the, 42
Seleucidæ, maritime discoveries of the, 42
Seleucus Nicator, his circumnavigation of Hindostan, and discovery of Taprobane, or Ceylon, 447
Semen Deshnew, the Cossack, his maritime discoveries, 483
Sepia. *See* Cuttle-fish
Serapis, temple of, 11
Serpents of the seas, 183
Serpulas, 266
Sertularia, 347
Shakspeare's Cliff, destructive action of the sea on, 30
Sharks, 198
— Greenland shark, an enemy of the whale, 99
— luminous, 330
Sheldrake, or burrow duck, 148
Sheppey, Isle of, rapid decay of the coast of the, 30
Sherringham, ravages of the sea on the coast at, 29
Shetland Islands, fury of the Atlantic waves at the, 28
Shetland, New South, discovery of, 509
Ship-worm (teredo), 302
Shore-crab, 251
Siberia, Cook's visits to the coasts of, 492
Sicily, submarine landscapes of the coast of, 21
Siphonostomata, 245
Skerries, cave in the, 51
Skerryvore lighthouse, 85
Skimmer, 169
Sledge-journey, arctic, 502
Sly, 202
Smeaton, John, his lighthouse on the Eddystone rocks, 83

Smooth-back whale, the antarctic, 102
Snake-stars, 437
Snow-goose, 146
Society Islands, discovery of the, 486
Soland goose, 156
Solasters, 334
Sole, 237
— skin of the, 190
Solen, or razor-shell, 304
Solis, Juan de, his discoveries, 461
— — — his death, 461
Solomon Islands, discovery of the, 473, 483
Souffleur, or blower, the marine cave of the, 52
Soundings, American method of taking, in deep water, 6
South Sea Islands, discovery of the, 4[illegible]
Speckled diver, 145
Sperm-whale, or cachalot, 102
Spiders, marine, 260
Spitzbergen, discovery of, 477
Spondylus, royal, 314
Sponge-crab, 249
Sponges, 385
— their remarkable growth, 385
— habitat of the common sponge, 388
Sprat, the, 214
Springs, origin of, 73
— mineral waters, 74
Springs of fresh water in the bottom of the sea, 17
Staffa, island of, 46
Stalactite caves of the island of Sardinia, 49
Star-fishes, 328
— their organisation, 328
Star-gazer fish, 202
Sterlet of the Volga, 217
Stevenson, Mr. Alan, his Skerryvore lighthouse, 86
Stevenson, Mr. Robert, his lighthouse on the Bell-Rock, 85
Stickleback, parental affectio[illegible] the, 195
Stone-corals, 373
Storm, the great, of 1703, 82
Storm-tides, 34
— devastations of, on flat coasts, 34, 35
Strand-birds, 143
— migration of, 144
— food of, 144
Strombus pes pelicani, 290
Sturgeons, 216, 217
— caviar, 217
Sucking-fish, 203
Suffolk, rapid decay of the cliffs of, 2[illegible]
Sun-fish, 232, 233
— its luminousness, 422
Sun, his influence on the tides, 37
Sun-star fish, 334
Surgeon-fish, the, 205
Sweden, gradual upheaving of the coast of, 10
Sword-fish, an enemy of the whale, 99
— his weapon, 201
Synchæta baltica, 269

TAHITI, discovery of, 484
Tailor-bird, the, 143
Taprobane, or Ceylon, discovery of, 447
Tartessus, Phœnician town of, 444
Tasman, Abel, his maritime discoveries, 480
Tasmania, discovery of, 481
Tectibranchiata, 284
Temperature of the sea, 13
— at various parts of the surface of the globe, 14
Teredo navalis, 302
Thames, progress of the tide-wave in the, 43
Thornbacks, 240
Thresher, or sea-fox, an enemy of the whale, 99
Thunder-stones, 437
Tide-wave, measurement of the depth of the sea by the rapidity of the, 8
— progress and course of the, 40, 43
Tides, the, 32
— description of the phenomenon, 32
— devastations of storm-floods on flat coasts, 34, 35
— knowledge of the ancients respecting the tides, 35
— fundamental causes of the tides revealed by Kepler and Newton, 36, 37
Tides, height of the, at various places, 38
— vortices caused by the: the Maelstrom, Charybdis, &c., 41
— the phenomena of the Euripus, 44
Tierra del Fuego, masses of sea-weed at, 394
— — — rounded by Schouten and Le Maire, 480
Tonga, discovery of, 481
Top, agglutinating, 296
Tornadoes, causes of, 68
Tornatella fasciata, 290
Torpedo, the, 201
Torres, his maritime discoveries, 480
Torso Rock, the, 9
Tortoise-shell, 180
Tortoises, 176
Trade-winds, the, 67
T[illegible]arency of the sea at Capri, 18
— — — in the Indian Ocean, 21

Transparency of the sea—*continued.*
— — — — — in the Caribbean, 21
Trepang, or Biche de Mer, 340
— mode of curing, 340.
— the fishery in the Feejee Islands, 342
Tridacna, the gigantic, 314
Trigger-fish, 233
Trilobites, 436
Trunk-fish, 232
Tubiporidæ, 370
Tubulibranchiata, 292
Tunicata, 316, 321
Tunny, the, 221
— stripe-bellied, 224
Turbot, the, 236, 237
Turn-stone bird, 144
Turtles, 173
— catching turtles in the island of St. Thomas, 172
Tynemouth Castle, destruction of the coast near, 29
Typhoons, causes of, 68
Tyrian dye, 446

ULVÆ, 391
Unicorn-fish, or narwhal, 106
Urasters, 334
Urdaneta, first reaches Acapulco from Manilla, 472

VANCOUVER'S discoveries, 472
Van Diemen's Land, discovery of, 480
Vanikoro, island of, 493
Velellæ, the, 353
Venice, maritime grandeur of, 450
Verazzani, voyage of, 461
Vermetus, 291
Virgularia mirabilis, 365
Vogtia pentacantha, 353

WALES, Cape Prince of, discovery of, 491
Wallis, his maritime discoveries, 483
Walrus, or morse, 117, 129, 135
— anecdote of a fight with, 130
— ivory of the, 132
Walton, his mussel-beds in France, 307
Water-snakes, 183
Water-spouts, causes of, 68
Waves of the ocean, 24
— wave-motion as distinct from water motion, 25
— height and velocity of storm-waves, 26–28
— Homer's picture of the breaking of the waves against the shore, 26
— Scoresby on the height of waves in the open sea, 27
— force and height of the waves on rocky coasts, 28
— instances of the destructive action of the tidal waves on coast-lines, 28–31
Weddell, Captain, his voyages, 509
Weevers, 204
Wellington Channel, discovery of, 500
Wentle-trap, Chinese, 289
Whalebone, 96
Whale-fishery, history of the, 109
Whales. *See* Cetaceans
Whelks, 292
Wilkes, Captain, on the height of waves, 28
Wilkes, his explorations, 509
Willoughby, Sir Hugh, his unfortunate arctic voyage, 474
Winds, origin of, 66
— trade-winds, 67
— calms, or doldrums, 67
— monsoons, 68
— typhoons, tornadoes, &c., 68
— water-spouts, 68
Wing-shells, 304
Winstanley, Mr., his lighthouse on the Eddystone rocks. 81
Winter Harbour, discovery of, 500
Wolf-fish, 197
Wolstenholme Sound, elevation of the coast at, 10
Worm-shell, 291

YORKSHIRE, wearing away of the coast of, 29
Yucatan, first exploration of, 461

ZOSTERA marina, 391

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